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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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GENERAL PHYSICS.

184. *Surface Tension of an Insulating Liquid in an Electric Field.* **A. Sellerio.** (N. Cimento, 11. pp. 297–304, May–June, 1916.)—The author has made measurements of the vapour tension of vaseline oil and olive oil in an electric field by the drop method. Two vertical metallic plates, about 12 cm. in diam. and 6 cm. apart, were connected with an electrostatic machine, the capillary tube joined by means of a wide rubber tube with a tapped funnel being placed between the plates. The number of drops to a volume given was determined with the plates alternately charged and discharged. The surface tension is found to be somewhat greater in the electric field than under ordinary conditions, the extent of the excess with vaseline oil being several per cent. for a field of 4000–5000 volts per cm. In the case of olive oil the difference seems to be rather greater. T. H. P.

185. *Viscosity of Insulating Liquids in an Electric Field.* **A. Sellerio.** (N. Cimento, 11. pp. 395–411, May–June, 1916.)—The author has made experiments on this question by the method of damped vibrations, a system being used which makes very rapid vibrations. The liquids examined were castor oil, carbon disulphide, and vaseline oil, and in each case the establishment of an electric field caused an appreciable increase in the viscosity. The amounts of these increases are: (1) with castor oil, approximately 2·4 % for 23,000 volts per cm.; (2) carbon disulphide, 5·3 % for about 12,000 volts per cm.; (3) vaseline oil, 6 % for 16,000 volts per cm. Possible objections to the experimental arrangements and to the conclusions drawn are discussed and answered. T. H. P.

186. *Application of Vortex Rings to the Determination of Surface Tension.* **V. Kutter.** (Phys. Zeits. 17. pp. 573–579, Dec. 1, 1916.)—The phenomena previously described [Abs. 1317 (1916)] may be utilised for the determination of the surface tension of liquids (compare Rayleigh, Roy. Soc. Proc. 29. p. 71, 1879; Webb, Mess. of Math. 9. p. 177, 1879.)—The apparatus employed is described and the precautions necessary to overcome certain difficulties are discussed. T. H. P.

187. *Absolute Value of the Coefficient of Viscosity of Air.* **E. L. Harrington.** (Phys. Rev. 8. pp. 738–751, Dec., 1916.)—The author has measured the coefficient of viscosity of air by means of the apparatus of Millikan and Gilchrist [Abs. 1577 (1913)] modified as regards the suspension and certain other features in order to adapt it to running in a vacuum. The adjustment and working of the apparatus were carefully controlled. A series of 31 determinations were made at various times during three months, six different suspensions being employed. The mean value obtained for η at 23° is $1822{\cdot}6 \times 10^{-7}$, the extreme values being $1820{\cdot}5$ and $1825{\cdot}9 \times 10^{-7}$, and the probable error, calculated by the method of least squares, is 1 in 9600. This result is in good agreement with that given by Millikan (*loc. cit.*). The determinations on which the higher value given by Vogel is based include some which certainly involve gross error and which are at least very far from what is now known to be the approximate value of η [Abs. 1187 (1914)].
T. H. P

188. *Failure of a Cylinder under Lateral Compression.* **J. Schmidt.** (Zeits. Vereines Deutsch. Ing. 60. p. 987, Nov. 25, 1916.)—For a cylinder of radius r the value of L in Euler's formula $P = \pi^2 IE/L^2$ is shown to be $\pi r/\sqrt{3}$ instead of $\pi r/2$ as hitherto assumed.
J. W. T. W.

189. *Torsional Vibration of Beams of Commercial Section.* **E. G. Ritchie.** (Roy. Soc. Edinburgh, Proc. 36. pp. 32–43, 1915–16.)—When a beam of commercial section is loaded centrally, and subjected to vibrations, the frequency of transverse vibration can be readily determined from a knowledge of the dimensions of the beam, its modulus of elasticity, and the conditions of loading. On the other hand, where the loading is eccentric, the transverse vibration is accompanied by a torsional vibration the frequency of which is very much lower than is indicated by the ordinary elastic theory, due to the inefficiency in torsion of beam sections other than circular. In practice it is not always possible to eliminate the eccentric loading of beams, as for instance where power is transmitted through countershafts supported from structural steel-work, and it is with the problem of the torsional vibration of such eccentrically loaded beams that the present paper deals. The subject is treated under the headings: Torsion of beam sections; Torsional vibration of beams; Fixed-free beam with single load at free end; Fixed-fixed beam with single load; Effect of inertia of beam; Beam loaded at more than one point; Beam loaded uniformly; Beam of non-uniform section.

Formulæ are derived and experiments on I-section beams described. The observed frequency of vibration is found to be in close agreement with the frequency as calculated from the formula using the *actual* polar moment of inertia; the frequency calculated from the *geometrical* moment of inertia shows a large discrepancy. A table gives the effective values of the inertia for various sections.

The investigation leads to the conclusion that beams of commercial section, when loaded non-centrally, may have a period of vibration commensurate with that of machinery in operation.
L. H. W.

190. *Some Simple Deformations of Homogeneous Partitionings of Space and the Increase of Internal Surfaces Generated thereby.* **E. Hatschek.** (Phil. Mag. 33. pp. 83–91, Jan., 1917.)—This investigation was originally undertaken to determine whether the generally received theory of the structure of gels

was compatible with the elastic properties of these bodies; this theory assumes that gels are systems of two liquid phases having interfacial tension. Since a number of gels show marked, and within narrow limits perfect, elasticity of form, it follows at once that, if the theory is correct, this elasticity can be due only to the interfacial tension of the phases, since either phase considered singly possesses elasticity of volume only. Deformation of a gel must lead to an increase of the interface or internal surface, and the tendency of the system to return to its minimum interface shows itself as elasticity. For a tensile strain W and elongation L, $W = C dS/dL$, where S is the interface, and C a constant containing both its absolute size and the interfacial tension. If, therefore, the function connecting elongation and increase of surface can be determined, the stress-elongation curve can be found by differentiation, and the curve so found can be compared with the experimental data. Should the curves show marked disagreement, the theory of two liquid phases is at once untenable. If a system of two liquid phases is to have approximately the appearance and some of the properties of a solid, the disperse phase must occupy almost the total volume—98 to 99 %—leaving only 1 to 2 % for the continuous phase, which therefore can form only a thin film separating polyhedra of the continuous phase. Although such a structure can hardly be in stable equilibrium, yet it exists in high-percentage emulsions and is known to persist for years, due to the very low interfacial tension which is a necessary condition for the production of such emulsions. The author considers he is correct in assuming that the geometrical character of the interface conforms to some type of homogeneous partitioning of space and that its elements are either 12- or 14-faced polyhedra. He determines the increase of surface produced by deforming such structures and plots the first differential coefficients of these increases as ordinates against the elongations, and so obtains the stress-elongation curves, finding them to show very marked disagreement with the experimental curves. He extends this geometrical investigation by a consideration of hexahedral partitioning. As regards the deformation, the only limitation is the condition of continuity that the polyhedra obtained from the minimum types must again fill space continuously. Numerous diagrams, tables, and curves are included in the paper. H. H. Ho.

191. *On the Relativity of Rotation in Einstein's Theory.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 19. pp. 527–532, 1917.)—Observations indicate that the relative accelerations of material bodies at the earth's surface differ from those which would be caused by Newton's law of gravitation only. The difference is explained by Newton's law of inertia, combined with the rotation of the earth relatively to an "absolute space." Newton quite deliberately introduces absolute space and time as an element of his explanation of observed phenomena. Objections against the above are based on the logical claim that a true causal explanation shall involve only observable quantities. It has been tried to replace the absolute space by the fixed stars, by the "Body Alpha," etc., but all these substitutes are on a par with the absolute space itself. Einstein also rejects the absolute space, but he apparently still clings to the "ferne Massen." The author opines that Einstein has made a mistake here. The general theory of relativity is in fact entirely relative and has no room for anything whatever that would be independent of the system of reference. The need for the introduction of the distant masses arises from the wish to have the gravitational field zero at infinity in any system of reference. This wish, however well founded in

a theory based on absolute space, is contrary to the spirit of the principle of relativity, and the author demonstrates this by a consideration of the fundamental tensor g_{ir}. Rotation is shown to be relative in Einstein's theory, but not physically equivalent to translation, the fundamental difference being that the latter is an orthogonal transformation (Lorentz-transformation) of the four coordinates, or world-parameters, and the former is not. New orthogonal transformations are the only ones that leave the line-element invariant in the coordinates, *i.e.* that do not affect the g_{ir}, and are therefore without influence on the gravitational field. Consequently linear velocity may be transformed away by a Lorentz-transformation, but not so rotation any more than mass, and this is a fact independent of all theories. For Einstein, who makes no difference between inertia and gravitation, and knows no absolute space, the accelerations which the classical mechanics ascribed to centrifugal forces are of exactly the same nature and require no more and no less explanation than those which in classical mechanics are due to gravitational attraction. H. H. Ho.

192. *New Knowledge on Standard Reservoir Mouthpiece.* **W. S. Pardoe.** (Eng. News, 76. pp. 520–521, Sept. 14, 1916.)—The author states that recent experiments conducted in the hydraulic laboratory of the University of Pennsylvania are of value in explaining the action of the water within a standard short tube and also in correcting many indefinite and erroneous statements contained in standard text-books on hydraulics. The tube used in the experiments was 2 in. in diam., 6 in. long, tapped for ⅛ in. pipe at 12 points spaced in an irregular helix. A common header was connected to the vacuum gauges, water being used for the lower negative pressures and mercury for the higher ones. Thirteen experiments were made with heads varying from 2·5 ft. to 47·5 ft. A series of curves is given. The author also discusses theoretically some of the results obtained. W. J. C.

193. *Collapse of Short Thin Tubes.* **A. P. Carman.** (Phil. Mag. 32. pp. 559–566, Dec., 1916.)—The problem of the collapse of tubes is to find an equation to express the relation between the collapsing pressure and the dimensions and elastic properties of the tube. In this general form no solution has been found, and it is probable that no simple solution is possible. From theory and experiment, however, fairly simple equations have been obtained (i) for long thin tubes, and (ii) for long tubes of moderate thickness. The term "long" is used for a tube whose length is beyond a certain critical length, which is generally taken as about six diameters. The thickness of the tube is expressed in terms of the ratio of the wall thickness t to the mean diam. d. If t/d is not more than about 0·025 the tube is ordinarily called "thin." "Moderately thick" tubes are those for which t/d has a value between 0·03 and 0·07. The experiments described in the present paper were made to obtain more data on the collapsing pressures of tubes, particularly near to and inside the critical bend in the curve for the relation between pressure and length. The tube to be collapsed was closed by end-plugs, and these were supported by an internal rod so as to eliminate end pressures on the tube when the tube was placed under external water pressure. Leakage to the inside of the tube was prevented by wrapping the joints with "friction" insulating tape, and covering the whole joint with asphaltum. End constraints were thus avoided. The tubes employed were seamless-drawn steel tubes of 1, 2, and 3 in. diam., and were carefully machined to different thicknesses. Experiments had previously been made

with small tubes of brass, aluminium, hard-rubber, and glass, and the curves obtained have similar forms to those for steel. The results obtained with the steel tubes are as follows:—(i) The curves for different thicknesses and diameters are all similar in shape. The very thin tubes show the greater variations, but this is to be expected owing to the difficulty in getting uniformity in thickness and material for thin tubes. (ii) By taking the point for the length of 6 diams. and drawing a hyperbola through this point, using the equation $p' = pL/l$, and taking p as the collapsing pressure at the length of 6 diams, there is, in most cases, a satisfactory agreement between the observed and calculated curves for lengths less than 6 diams. For lengths greater than 6 diams. the calculated pressures are increasingly less than those given by experiment. The length of 6 diams. thus appears to be a critical length. (iii) The experimental curves are not in agreement with the Southwell formula $L = k\sqrt{(d^3/t)}$, which Cook has used. The curves for seamless steel tubes, for which the ratio t/d is between 0·0245 and 0·015 show that there is a critical bend at the length of about 6 diams., the part of the curve for the shorter lengths being a rectangular hyperbola. Beyond this critical bend the curve approaches more or less rapidly to a straight line parallel to the axis of abscissæ. A. W.

194. *Temperature Coefficient of Gravity.* **F. A. Lindemann** and **C. V. Burton.** (Nature, 98. p. 349, Jan. 4, 1917.)—In 1916 P. E. Shaw published an account of a research from which he deduced that the gravitational constant is increased by one part in eighty thousand when the temperature of the larger mass is raised one degree [see Abs. 860 (1916)]. According to the experimenter's interpretation of his results, it is the mean temperature of the system which affects the coefficient of attraction, so that in the case of extremely unequal masses it is the temperature of the larger mass only which counts. The evidence does not seem strong enough to support so revolutionary a conclusion in view of the almost insuperable theoretical objections.

One or two of the more obvious difficulties may be formulated briefly.

Take as an example the earth and a mass of 1 kg. Divide up the earth (ideally) into "terrestrial particles" of, say, 1 mgm. each. When the temperature of the kilogramme mass alone is raised one degree, its attraction for each "terrestrial particle" should be increased proportionally by $1{\cdot}2 \times 10^{-5}$. But by the same reasoning the attraction between the kilogramme mass and the earth as a whole should remain sensibly unaltered. In like manner, if we keep the kilogramme mass at constant temperature and alter the temperature of the earth, the attraction between the kilogramme and each "terrestrial particle" will be sensibly unaltered, while the attraction between the kilogramme and the earth as a whole will have changed. This seems so essentially paradoxical that it is difficult to conceive of any supplementary hypothesis elastic enough to reconcile the contradiction involved. The only way of avoiding this inconsistency is to admit that it is the product of the two values of a temperature-function which counts—*i.e.* that the temperature of the smaller mass is just as important as the temperature of the larger mass. Once this is admitted the experiments of Poynting and Phillips prove that no variation exists greater than 10^{-9} per 1 deg. C.

Again, it has been suggested by E. H. Barton that the temperature of the intervening radiation might affect the attraction. But the temperature of radiation is independent of the intensity, so that indefinitely feeble radiation would produce a finite effect.

If the intensity of the radiation is substituted as the determining factor, it implies that the attraction of two bodies is increased if a beam of light passes between them. If energy is to be conserved, this would imply that two bodies moving relatively to one another could increase or diminish the energy of a beam of light passing between them, and such a result would certainly be rather startling. Still more extraordinary would it be to find that a variation of 0·01 of a stellar magnitude on the part of the sun would change the length of the year by several minutes ; yet this is what would be implied. There is no record of an appreciable change in the earth's orbit caused by sun-spots.

When we come to examine the evidence out of which all these paradoxes arise, it can scarcely be said to be sufficient. Thus from C. V. Boys' work on the gravitation constant, P. E. Shaw deduces a temperature-coefficient of 10^{-8}, of which, according to his own results, 98·7 per cent. must be ascribed to error. Can we have much confidence in the remaining 1·3 per cent. ?

While admiring the experimental skill which enabled P. E. Shaw to observe a change of 0·2 mm. at either end in a range of 200 mm., using a telescope and scale, especially when they know the difficulties he had to contend with, the present authors feel they can scarcely be expected to make these radical changes in theory on the strength of such a very small effect. They feel that as the outcome of such an elaborate research a null result is quite as important as a positive one, though less sensational. To have reduced the apparent temperature coefficient of gravity from the 10^{-8} derived from Boys' measurements to one-eightieth of that value they consider is no mean achievement.

P. E. Shaw. (Nature, 98. p. 350, Jan. 4, 1917.)—Replying to F. E. Lindemann and C. V. Burton, the author defends the dependence of the gravitative attraction on the weighted mean temperature as follows :—If M, m, μ are the masses of earth, kilogramme, and milligramme we have the cases cited thus. When m alone rises in temperature the increment of its force on μ is $Gm\mu aT/d^2$, and on M is $GmmaT/d^2$. The first is sensible, the second insensible, compared with the forces when cold. Again, when μ alone rises in temperature the increment of its force on m is $G\mu\mu aT/d^2$, but the increment of the force of M (considered as an aggregate of μ particles) on m is $G\mu\mu aT/d^2$, multiplied by

$$\frac{M}{\mu}\cdot\frac{M}{M+m}\cdot\frac{\mu+m}{\mu}=GMmaT/d^2.$$

This is identical with the increment of force on m due to M (considered as a whole), and is sensible compared with the force when cold. It is thus claimed that the series forms a consistent whole.

It is not considered that the authors' results and those of C. V. Boys admit of a simple comparison, since, in one case, only the big masses were heated, while in the other all the masses were heated. E. H. B.

195. *Use of a Flagpole in Calibrating Kite Anemometers.* **B. J. Sherry.** (Monthly Weather Rev. 44. pp. 327–328, June, 1916.)—It has been the custom to calibrate kite anemometers by hanging them below a wind vane and comparing with the readings of a standard Robinson anemometer close by. Some uncertainty has remained as to whether when the instrument was hung within a kite the deflection of the air caused by the planes would affect the readings. To test this the meteorograph was hung in its normal position in a kite and the latter flown by a short cord from the top of a flagpole, a standard anemometer being mounted alongside at the same height. The two methods of calibration led to the same result, showing that the kite planes did not appre-

ciably affect the readings. The use of the pole was also found convenient for testing faulty kites. The motion of the kite was watched from the ground close by and the cause of the bad flying detected. J. S. Di.

196. *The Compression of the Earth's Crust in Cooling.* **H. Jeffreys.** (Phil. Mag. 32. pp. 575–591, Dec., 1916.)—The principal cause of the elevation of continents and mountains has been ascribed by geologists to a state of horizontal compression of the earth's crust under which it frequently gives way, the strata being then folded into a shorter length in the neighbourhood of the point where the weakness has been shown. Such a compression appears to be the only mechanism that has been suggested to be qualitatively capable of producing the observed results. The cause of the compression itself is, however, very uncertain. The contraction hypothesis is the most satisfactory of those that have been offered, but grave doubts have frequently been expressed about its quantitative adequacy. Previous estimates by G. H. Darwin and Davison rested on Kelvin's theory of the cooling of the earth. From radio-activity considerations, however, it has been shown that so much heat is actually being generated within the earth's crust, that if the same amount per unit volume were being produced throughout the mass, the temperature gradient at the surface would be 300 times its actual value, and the earth would be getting hotter instead of colder. There are many objections to this view, and it seems that the amount of radio-active matter per unit volume must decrease so rapidly with depth that the total is insufficient to supply more than about ¾ of the present loss of heat from the surface. From a review of the evidence obtained by several different lines of investigation, Holmes has found that the observational data can be satisfied exceedingly well if the age of the earth be taken to be about 1600 million years, and if the rate of liberation of heat per unit of volume decrease exponentially with the depth. The interval of time concerned is so much greater than that found by Kelvin that his theory of cooling requires to be revised so as to take into account our most recently acquired data, and at the same time the contraction theory, which depends on it, needs similar revision. This is the principal object of the present paper.

The level of no-strain is found now to be at a considerably greater depth than the older determinations gave, and at the same time the amount of compression at the surface is much increased. For both reasons the volume of crumpled rock is increased. On the basis of the exponential distribution of radio-active matter the available compression is 133 km., *i.e.* enough to shorten every great circle of the earth by this amount. Actually, folding is not uniformly distributed over the earth, but nearly confined to certain definite lines of weakness, and in the valleys of East and Central Africa a tension is actually indicated. Some great circles thus show very little crumpling, and others are free to be folded to a greater extent than would be possible if the distribution of mountains were uniform. When a numerical estimate is made of the amount of compression required to produce the known mountain ranges, that found to be available on the contraction hypothesis appears to be quite adequate. The author gives a mathematical investigation into the effect on underground temperatures of a uniform distribution of radio-active matter through a horizontal layer, as also of other distributions of radio-active matter where the restriction is removed that the liberation of heat by such matter is assumed to be given by a special law of uniform distribution down to a particular depth and zero below. If it be assumed that throughout the process of cooling the earth preserves a state of spherical symmetry, then since the changes of temperature are not the same at all points, a state of strain must be set up consequent on the variations of volume that take place. This straining of the crust in cooling receives detailed mathematical attention. An examination of the amount of compression required to produce existing mountains is also undertaken. The author states that the elevation of a continent or a large tableland involves little crumpling within it, and no great amount at the coast so long as the slope is there gradual, so that in determining the amount of compression only the steep slopes of mountains need be considered. The theoretical and observed compressions are of the same order of magnitude; it thus seems highly probable that the contraction hypothesis is adequate to account for a very large fraction of the mountain-building that has taken place, and perhaps for the whole of it. The influence of denudation and thermal blanketing is examined at some length. An oceanic area is found to require round its margin a smaller horizontal pressure than the mean if it is to remain spherical, while a continental area requires a larger pressure. As the pressures must be equal, it follows that the earth cannot remain spherical. The only way in which this can happen is by a reduction of the radius of curvature of the crust, *i.e.* the continents will tend to rise and similarly the ocean-bed will sink. The effect capable of being thus produced is very great. The adjustment of the figure of the earth to make the compression constant all over is not likely to be complete and the remaining part of the differential compression will be shown in extra folding in the continents, and diminished compression, or even, in extreme cases, a tension in the ocean-bed. A section of the paper is devoted to the causes of isostasy, and the author goes into the difficult problem of how the continents and ocean basins ever came to be formed. If there were no isostatic compensation, they might be attributed to crumpling by compression of a type not very different from that which produces mountain ranges. Continental areas, though varying enormously in height and shape, are fairly permanent in position and their height is really due to their being made of lighter materials than the ocean-bed. The question is to decide how the lighter materials succeeded in being collected to certain points, leaving the denser rocks exposed in other parts, and Jeans's theory of Gravitational Instability, which the author considers to be the most satisfactory extant, is examined at some length. The concluding section is devoted to the effect of changes in the rotation of the earth. The truth of the theory of Tidal Evolution follows as a natural consequence of the present paper, and must therefore be considered with it. H. H. Ho.

197. *The Lava Eruption of Stromboli, Summer-Autumn*, 1915. **F. A. Perret.** (Am. J. Sci. 42. pp. 443–463, Dec., 1916.)—The recent phase of exceptional activity at Stromboli differs from that of 1891 in the relative proportions of the different phenomena, the earlier eruption having been characterised by a far greater degree of seismic and explosive activity, while the recent phase was remarkable for its long-continued outpouring of lava. The latter furnished a precious opportunity for the study of the important question of the behaviour of incandescent lava in contact with water. A comprehensive account is given of the initiation and progress of the eruption, which lasted 5 months and manifested powerful explosive phenomena only in the latest phase. A detailed description is given of the formation and configuration of the crater which consists of four main divisions, a disposition permitting and producing in its perfection that separating and segregation of gas and liquid—the first rising and escaping through the central crater, and

the second flowing out laterally—which so greatly affects the character of an eruption. As a result the lava issues from its tunnel already freed of those large bubbles of gas at high tension which are the cause of the explosions at the crater, and there results a quiet flow. Although the gas content is still high, it is either in solution or in the form of innumerable tiny vesicles in which the tension is too small to exert further influence upon the form of the viscous mass, and the lava possesses, in great part, the qualities of the *pahoehoe* type. On the basis of the degree of incandescence the author estimates the temperature at 1100° C. The solidified lava is a very dense, black basalt, which shows, in an evidently vitreous ground mass, many small phenocysts of augite, few of olivine, and none of felspar. A table is given showing its chemical composition as contrasted with those of other recent Stromboli basalts. The composition of the lavas of the basaltic phase has remained very uniform. The author coated specimens of the basalt, taken incandescent from the flow, with paraffin as soon as they were sufficiently cool, in order to prevent diffusion of gases from the interior, and it is hoped that this lava, when heated *in vacuo*, will yield its original gas-content for analysis. Direct collection of gas by any other means was not feasible. The behaviour of the lava stream on coming in contact with the water of the sea and during its continued flow as a sub-aqueous stream, not only sheds light upon the manner of growth of the many volcanoes which have begun their existence at the bottom of the sea, but also is important on account of the paramount question of the absorption of water by hot lava and any subsequent chemical or physical changes. Massive, highly incandescent lava, free from large gas-bubbles, when entering water slowly, does so with an absence of explosive phenomena or of serious commotion which at first is very surprising. Even with a perfectly calm sea there was rarely a continuous and uniform evolution of vapour. A sub-aqueous lava comporting itself as quietly as when sub-aerial is due to the formation—by rapid cooling through contact with a cold, conducting liquid of great heat capacity—of a porous lava sheath of low heat conductivity, which intervenes to hinder the free passage of heat into the water. A sheath of water-vapour (spheroidal state) will also suggest itself as a heat insulator interspersed between the hot lava and the water, but this well-known phenomenon, under the conditions here prevailing, is of such short duration that its influence to protect the flowing lava stream must be accounted secondary. This fact of the protective sheath is important for the explanation of the quiet growth of submarine volcanoes. The explosive phenomena are dealt with at some length and the paper is illustrated by 10 photographs. From a crater in moderate activity the form of the gaseous emanations is found to depend upon the weather, and the usual explanation is that the water-vapour in the volcanic exhalations is absorbed in a dry atmosphere but condenses in contact with moist and already saturated air; the author, however, has long suspected the atmosphere itself to be the source of this water-vapour. He finds that the volcano brings about nucleation of saturated vapour from without, and that the great cloud of water-vapour is not an emanation of the volcano but a condensation from the atmosphere upon nuclei furnished by the stream of dust particles and aided by direct ionisation. Precipitation of salts from gas emanations was not marked during this eruption, excepting in the fumarolic area, towards the end. There was evidence during the eruption of response to the influence of favourable luni-solar combinations. H. H. Ho.

198. *Parallaxes of Two Stars with Common Motion.* **O. J. Lee.** (Astron. J. 30. p. 6, Oct. 2, 1916. Nature, 98. p. 317, Dec. 21, 1916. Abstract.)—Two

stars found by Adams to have similar proper motions and radial velocities have been examined for parallax, and it is shown that they differ considerably in this respect. The radial velocities are very great, about 800 km./sec.

C. P. B.

199. *Extra-focal Stellar Photometry.* **R. H. Baker** and **[Miss] E. E. Cummings.** (Laws Observatory Bull., No. 24. Nature, 98. p. 379, Jan. 11, 1917. Abstract.)—Observing with a 5-in. photographic doublet attached to a 7½-in. refractor, tests of the accuracy available in extra-focal photometry have been made on 8 plates containing double exposures on selected circumpolar regions, furnishing 196 stars for measurement. The star images ranged from 0·3 to 0·5 mm. in diam., and the resulting probable error of a single observation is given as 0·05 magnitude. Twelve eclipsing variables are under observation. C. P. B.

200. *Clouds on Mars.* **W. H. Pickering.** (Popular Astronomy, 24. p. 639, 1916. Nature, 98. p. 397, Jan. 18, 1917. Abstract.)—Observations made by members of an international organisation are summarised with special reference to clouds observed on the planet during the opposition of 1916. These were always seen over the so-called desert regions of the disc.

C. P. B.

201. *Rotation Period of Tropical Disturbance on Jupiter.* **F. Sargent.** (Roy. Astron. Soc., M.N. 77. pp. 68–71, Nov., 1916.)—Attention is drawn to an oscillation in the period of rotation of the Great South Tropical Disturbance on Jupiter. It has been noticed that the rotation periods for the ends of the structure have been longer during the time of its visibility than during the time when Jupiter has been lost in the sun's rays. At the same time it has been found that observations of the Red Spot Hollow show no such oscillation. A tentative explanation is given ascribing the effect to projection of the shadow of the South Tropical Disturbance on the lighter surface of the planet. C. P. B.

202. *Meteor System of Pons-Winnecke's Comet.* **C. P. Olivier.** (Roy. Astron. Soc., M.N. 77. pp. 71–75, Nov., 1916.)—This comet was first discovered by Pons on 1819 June 12, and again by Winnecke on 1858 March 8, at Bonn. It has since reappeared in 1869, 1875, 1886, 1892, 1898, 1909, and 1915. The comet belongs to Jupiter's family, and, approaching at times very near to that planet, has suffered perturbations which have greatly changed its orbit. From an analysis of the available elements, it is found that the perihelion distance increased from 0·77 in 1858 to 0·97 in 1909. From the analysis of the meteor radiants observed in 1916 May 20 to July 10, in England and America, such close agreement with the cometary elements is shown that there seems to be no doubt that the earth was at that time passing through the outlying meteors of the cometary system. Observations are suggested in 1917 May and June. C. P. B.

203. *Long-period Variable Stars.* **T. E. R. Phillips.** (Brit. Astron. Assoc., J. 27. p. 2, 1916. Nature, 98. p. 336, Dec. 28, 1916. Abstract.)—An analysis is given of the light-curves of 80 variable stars, and the author finds that they fall into two distinct groups. In Group I the intervals from maximum to minimum, and from minimum to maximum are not very unequal, and there is a tendency to show a pause on the rise of the curve. In Group II there is a sharp rise to maximum, followed by a long period of decline. The stars of Group I are brighter than those of Group II.

C. P. B.

204. *Internal Motion in Spiral Nebulæ.* **J. H. Jeans.** (Observatory, No. 509. pp. 60–61, Jan., 1917.)—Following the results of van Maanen [Abs. 117 (1917)], it is pointed out that Roche showed how a rotating gaseous mass with high central condensation would get flatter and flatter owing to shrinkage, until it became lenticular with a sharp periphery, after which matter would be ejected from the periphery. This view neglects tidal forces from distant stars, which, although small, may be represented by second harmonic terms, and tend to accelerate the effect; also to localise it at two antipodal points on the periphery. To a first approximation an ejected particle will describe an elliptic orbit of small eccentricity, and ultimately fall back to the main mass, but if tidal friction be considered it is found that such a particle will be gradually driven away from the main mass. On this view the nebular mass begins by being a lens-shaped figure in rotation, with matter streaming out at two opposite points and proceeding along spiral arms. The apparent angular velocity will decrease as the point examined passes along the arms, so that the spiral will appear to uncurl. The knots found on the arms are ascribed to the action of gravitationally unstable wave-motion.
C. P. B

205. *Confirmation of Darwin's Tidal Theory.* **G. Armellini.** (Observatory, No. 509. pp. 62–63, Jan., 1917.)—Acceptance of Darwin's theory of bodily tides leads to the view that the lunar crust formed when the moon was at a less distance than its present distance. In work on the form of the lunar spheroid the author finds certain discrepancies in the relationships of the three principal moments of inertia, which are lessened by applying the results of Darwin's theory, as the lunar crust, having become solid when at a certain distance from the earth, ceased to be an equipotential surface when the distance altered, and enormous internal strains were produced.
C. P. B.

206. *Peculiar Stellar Spectra.* **[Miss] A. Cannon.** (Popular Astronomy, 24. p. 656, 1916. Nature, 98. pp. 417–418, Jan. 25, 1917. Abstract. Paper read before the Amer. Astron. Soc.)—In all the classes of stellar spectra examined, involving some 218,000 stars, peculiar features occur involving special intensification or reduction of certain lines. An interesting record is that in the star C.P.D.—59° 3038, mag. 7·2, there is a strong line near λ3969, which may be a reversal of a prominent nebular line. Definite changes in spectrum are recorded in the stars η Carinæ and R Scuti, the latter being of class G 5 at maximum, changing to M 6 at minimum. A new type of spectrum is exhibited by a red star BD + 43°·53, the spectrum consisting entirely of light near H_α. C. P. B.

207. *Orbit of Spectroscopic Binary σ Puppis.* **J. Lunt.** (Astrophys. J. 44. pp. 260–262, Nov., 1916.)—The variable radial velocity of this star was announced by Palmer from photographs taken in 1904 at Santiago. Thirty-three plates of the spectrum were obtained at the Cape Observatory between 1909 Jan. 4 and 1915 March 11, and the analysis of these furnishes confirmation of the variability. Data are given providing a preliminary determination of the orbit. The period is 258 days. C. P. B.

208. *Total Solar Eclipse* 1914 *August* 21. **A. Miethe, B. Seegert, and F. Weidert.** (Phys. Zeits. 17. p. 571, Nov. 15, 1916.)—The note is a review of the publication of the observations made during the total eclipse of 1914 Aug. 21 in Norway, with details of the apparatus used, some of which was of considerable power. The results are not discussed. C. P. B.

209. *Cepheid Variables.* **Ludendorff.** (Astron. Nachr. No. 4869. Nature, 98. p. 397, Jan. 18, 1917. Abstract.)—Results are given of further investigations of the relations between the orbital elements of Cepheid variable stars, with an empirical formula, involving the eccentricity, angle from periastron to node, period in days, and half the amplitude of radial velocity. C. P. B.

210. *Movements of Minor Planets.* **H. v. Zeipel.** (Ark. för Nat. Astron. och. Fysik, Stockholm, 11. No. 1. pp. 1–58, and No. 7. pp. 1–62, 1916.)—The paper is in two parts, and consists of a long analytical discussion of the motions of the minor planets. C. P. B.

211. *Law of Luminosities in Globular Cluster M 3.* **H. v. Zeipel.** (Ark. för Mat. Astron. och. Fysik, Stockholm, 11. No. 22. pp. 1–17, 1916.)—Counts have been made of the numbers of stars of various magnitudes on photographs of the cluster M 3, taken at several observatories, and a discussion is given of the results with the object of ascertaining the law of distribution. The question is somewhat complicated by the fact of variables being present among the component stars of the cluster.

C. P. B.

212. *Determinations of Photographically Effective Wave-lengths in Spectra of Fixed Stars.* **O. Bergstrand** and **B. Lindblad.** (Ark. för Mat. Astron. och Fysik, Stockholm, 11. No. 17. pp. 1–23, 1916.)—The authors have employed a new astrograph, presented to Upsala Observatory, for determining the colour equivalents of fixed stars by measuring the photographically effective wave-lengths in their spectra according to the method previously used [Abs. 1195 (1909)]. That $\Delta\lambda$ follows different laws for white stars and for yellow stars is confirmed, the curves representing λ as a function of D being dissimilar in type. In order to take account of such Purkinje-effect in the reduction of the measurements, either (1) it may be eliminated by fixing a certain normal image strength and of the different exposures to employ only that which gives this image strength or one very close to it, or (2) from the curves mentioned corrections may be deduced to reduce all the measurements to the normal strength of image. Both methods exhibit difficulties and the most satisfactory solution is a compromise between the two.

Comparison of the results of the measurements with those previously obtained with the Meudon reflector indicate the applicability of the triplet objective for the determination of effective wave-lengths over a wide range. The results show that, of all the white stars none has an effective wave-length greater than $425{\cdot}0\ \mu\mu$, whilst of the yellow stars none has an effective wave-length less than $430{\cdot}9\ \mu\mu$; the interval between these two values contains no stars. It might be thought that this sudden jump in the effective wave-length is a purely photographic effect, depending on how the spectral intensities with different stars are situated with regard to the sensitivity curves of the plates. There are, however, certain circumstances which indicate that this is not the case and that, in the main, stars may be divided into two large, distinct classes, white and yellow. That a continuous transition in development from the one class to the other occurs cannot be denied but the period during which stars are found in the transition state would seem to be comparatively short and the whole number of stars simultaneously in this state only small. T. H. P.

LIGHT.

213. *Graduated Sphere for Problems in Crystal Optics.* **C. H. Warren.** (Am. J. Sci. 42. pp. 493–495, Dec., 1916.)—Describes, with photograph, an eight-inch graduated sphere for use in work on crystal optics. After turning, the sphere was enamelled, and then polished with pumice and water. Vertical and horizontal meridians, 10 degrees apart, were then ruled on it in black. The sphere was then mounted in a felt-lined cup so that it could be rotated rigidly about its vertical axis, or moved in any desired direction. Three graduated metal scales were then added, two vertical and one horizontal, and one of the vertical scales was arranged so that it could be rotated about its horizontal diameter through an angle of 125°. With the sphere made and graduated in this way, any of the usual problems met with in crystal optics where spherical projections are used may be quickly solved. A. W.

214. *Semi-transparent Mirrors.* (El. World, 68. pp. 1205–1206, Dec. 16, 1916.)—Describes the method employed in the research laboratory of the Eastman Kodak Company for making, by kathodic deposition, mirrors transmitting a given percentage of light, the size of the mirrors ranging up to 11 in. square. The glass plate to be coated with the metallic deposit is supported on glass pillars parallel to and a short distance above the kathode, which consists of a thin metal sheet, usually Pt 70 %, Ir 30 %. A bell-jar encloses anode, plate, and kathode, and after exhaustion the discharge is passed for a length of time depending on the current and the degree of transparency required. A. W.

215. *Focometry of Lens Combinations.* **A. Anderson.** (Phil. Mag. 33. pp. 157–159, Jan., 1917.)—Describes a modification of the nodal-slide method of determining the focal length of a lens combination, based upon the principle that if P_1 and P_2 be object and image there is one, and only one, line about which the combination may receive a small rotation without producing a displacement of P_2. This line intersects the axis of the combination in a point O such that $OP_2/OP_1 = m$, the magnification. The position of O can be found with the nodal slide, and then OP_1 and OP_2 can be measured, thus determining the magnification. The combination can then be displaced, the new position of O found, and the corresponding value of the magnification. The focal length and constants of the lens combination can then be found by calculation. J. W. T. W.

216. *Reflection Coefficients of Metals for the Polarised Components of Light.* **R. B. Wilsey.** (Phys. Rev. 8. pp. 391–401, Oct., 1916.)—In order to test the theory of metallic reflection, Tate [see Abs. 1181 (1912)] compared the reflection coefficients at *normal* incidence obtained by both the polarimetric and the photometric method upon the *same* mirrors. It has been found that determinations upon *different* mirrors of the same metal will, in general, not agree, owing to individual properties of the surfaces. Tate concluded that polarimetric determination of the coefficients was reliable, and much more accurate than photometric determination. The purpose of the present investigation was to test more completely the adequacy of the

polarimetric method, by extending the investigation to the component vibrations parallel and perpendicular to the plane of incidence, at various angles incidence. The method followed was the one used by Tate [Abs. 1181 (1912)], namely, the practically simultaneous determination of the reflection coefficients of the same mirror by the polarimetric and the photometric methods. The apparatus was the same—the Tool polarimeter [see Abs. 1427 (1910)] and the Brace spectrophotometer with the special reflecting device. The only addition was the introduction of a Glan air nicol in the reflecting system to polarise the light incident upon the mirror; this nicol could be rotated through 90°. The reflection coefficients obtained with the photometer had a probable error of 1 to 2 per cent.; those with the polarimeter were about ten times as accurate. The relations between the refraction and absorption coefficients of the medium for any given angle of incidence, and the corresponding constants for normal incidence, are got from Ketteler's equations. Observations were made upon a steel mirror taken from a König tuning-fork, and upon gold mirrors electroplated on speculum metal. The smallest angle of incidence used was 40°, owing to the difficulty of measuring the small ellipticity produced at small angles of incidence. Measurements were made firstly for a fixed wave-length ($580\,\mu\mu$ for steel, $620\,\mu\mu$ for gold), varying the angle of incidence; secondly at a fixed angle of incidence 60°, varying the wave-length. The results obtained, which are shown in both tabular and graphic form, show good agreement between the values of J_s, J_p, calculated from the polarimetric values, and their values directly observed with the spectrophotometer. J_s and J_p denote the reflection coefficients for the components of vibration perpendicular to, and in, the plane of incidence. The one exceptionally poor divergence of 5·7 per cent. occurs on the steepest portion of the gold curve, and the average difference between the observed and calculated values is only 1 or 2 per cent., being within the errors of measurement. It is noticed, however, that the value of the coefficients of refraction and absorption for normal incidence, calculated from polarimeter observations at different angles of incidence, do not agree within the errors of measurement; the former show a marked decrease for the larger angles of incidence. This discrepancy is attributable to imperfections in the surface of the mirror having greater effect when viewed at the largest angles of incidence. The most consistent values were found for incidence 40° to 70° with steel, and for 60° to 80° with gold. It seems quite likely that polarimetric measurements on the mirror at any angle of incidence might give correct reflcetion coefficients for that particular angle, but that the calculation therefrom of the constants for other angles (using Ketteler's equations) might not give correct values. However, the observations show that the theory holds very well for the best mirrors. A. E.

217. *Relation between Lines of the same Spectral Series.* **W. M. Hicks.** (Astrophys. J. 44. pp. 229–235, Nov., 1916.)—The very accurate determination of the wave-lengths of the first 57 members of the principal series of sodium by Wood and Fortrat [Abs. 562 (1916)] affords data which help to throw some light on the question as to the nature of the formulæ giving series lines, or as to whether in fact such formulæ actually exist. The frequencies of any of the recognised series can be approximately given by a formula of the type $\nu = A - N/[f(m)]^2$, and the author has shown that, with the exception of a few cases only, the form $f(m) = m + \mu + a/m$, suggested by Mogendorff and by himself, gives the frequencies to a few hundredths, except in many cases for $m = 1$, and that it is in fact better than the Ritz formula used by Wood and Fortrat. The importance of Wood and Fortrat's measurements is that even up to $m = 54$ they are probably correct to within a few thousandths of an Å.U. Hence the last six preceding this may be used to calculate asymptotically the value of A, and thus obtain the true numerical value of $f(m)$ for any line, independent of any supposition as to its general form, and only affected with the single observational error of the line itself. In this way the following formulæ were obtained for P_1 and P_2 respectively :—

$$P_1 : \nu = 41449{\cdot}00 - N/[m + 1{\cdot}148088 - 0{\cdot}081215/m]^2$$
$$P_2 : \nu = 41449{\cdot}00 - N/[m + 1{\cdot}147256 - 0{\cdot}081126/m]^2.$$

The values of $\delta\lambda$ = calculated — observed wave-lengths are given in tabular form, together with the corresponding values deduced from Wood and Fortrat's paper. The deviations shown by the last three lines from their calculated values are so large that they can scarcely belong to the typical P series. The first and third of these agree with the Ritz combinations $s(1) - d(55)$ and $s(1) - d(56)$. It is not clear what relation the second has to known sequences. It is seen from the table that if the observational errors do not amount to more than a few thousandths of an Å.U., neither formula is sufficient to the degree of accuracy here in question, although that in α/m gives slightly better results than in β/m^2. The results are further discussed in relation to the author's previous work [Abs. 1959 (1913)], and attention is drawn to the importance of using the same instrument in Weiss's laboratory to extend observations to the elements K, Pb, Cs ; for Bevan has shown that Wood's method is applicable to all the alkalies as well as to Na. A. W.

218. *Table for Linear and certain other Interpolations on Spectrograms.* **H. E. Merwin.** (Am. J. Sci. 43. pp. 49–56, Jan., 1917.)—In the table given in this paper each wave-length λ has a definite value for each value of a quantity $n' = [0{\cdot}01/(\lambda^2 - 0{\cdot}01)] - 0{\cdot}01\lambda^2$, where λ is expressed in μ. On a spectrogram λ for each line has a corresponding value of d, the distance of the line from some chosen line. The relation of the values of n' and d for the same λ is represented more or less approximately by the linear expression $d_\lambda = Kn_\lambda - R$, where K and R are constants determined for each spectrogram. Three cases occur : (i) where deviations from this linear equation are within the limits of observational error ; (ii) where the deviations are small but not negligible ; (iii) where the deviations are so large that a plotted deviation curve does not give accurately the required corrections. Case (iii) can, however, be modified so as to come under (i) or (ii). Case (i).—The equation is solved for K and R by using d and n' for the wave-lengths of two comparison lines near the extremities of that portion of the spectrogram to be studied. Then for other values of d, values of n' are calculated, and the corresponding wave-lengths read from the table. Values of λ thus obtained agree with values known from other comparison lines on the spectrogram. Case (ii) is like case (i) except that values of λ for intermediate lines deviate slightly from the true values, but the deviations fall on a smooth curve from which proper connections can be read. Case (iii) is like case (ii), but the deviations are too large to handle accurately if the table is used as it stands. But, instead of reading from the table n' corresponding to λ of the spectrogram, we read n' corresponding to $\lambda + k$, where k is small compared with λ. The value of k depends upon the type of spectrograph used, and in some cases on the part of the spectrum photographed. When only a few comparison lines are available the values of λ obtained from the table are more accurate than those obtained by Cornu's or Hartmann's formula. A. W.

219. *Photography: the Half-tone Process.* **A. J. Bull, W. J. Smith,** and **E. L. Turner.** (Phot. J. 57. pp. 8–16, Jan., 1917.)—Experiments made to ascertain the effects of the several variable factors (more than twenty in number) in the commercial half-tone process. A. D.

220. *Convergence Wave-lengths in Spectral Series and Atomic Radii.* **F. Sanford.** (Astrophys. J. 44. pp. 201–209, Nov., 1916.)—It can be shown that Einstein's photoelectric equation leads, on certain assumptions, to the following equation giving R, the electronic radius, in terms of λ, the wave-length: $R^2 = 1{\cdot}1\lambda \times 10^{-11}$. For purposes of comparison it may be assumed that the orbital radius corresponding to the convergence wave-length represents the radius of the central positive mass outside which all the electrons of the system are moving. A comparison of values obtained in this way with Heydweiller's atomic radii does not show strict proportionality between the two, though within each group of similar elements the proportionality is very close. It can also be shown that the Heydweiller radii are, within similar groups, very closely proportional to the square-roots of the convergence wave-lengths. Another relation between the atomic radius and the constants used in computing wave-lengths may be found in the Ritz formula. Taking the form $\nu = A - N_0/(n + a + b/n^2)^2$ and plotting the values of the constant a against the corresponding atomic radii, it is seen that a marked proportionality exists. There seems to be no doubt that the Ritz constant a is a simple function of the atomic radius. A. W.

221. *Graphical Construction for obtaining the Wave-lengths in Prismatic Spectra.* **F. Henroteau.** (Roy. Astron. Soc., M.N. 77. pp. 77–81, Nov., 1916.)—In the case of prismatic dispersion the Hartmann formula $\lambda = \lambda_0 + c/(R_0 - R)$ (where R is the micrometer reading, and λ_0, c, and R_0 computed constants) gives good results for the value of λ. As a rule, then, only small corrections have to be made. But if a number of values of λ have to be computed by means of Hartmann's formula a good deal of time is taken up. The graphic method here given is very simple, each wave-length being obtained by the tracing of only one straight line. The Hartmann equation may be written $(\lambda - \lambda_0)(R - R_0) = c$, which is the equation of a rectangular hyperbola. Consider a branch of this hyperbola and its two asymptotes as_1, as_2. Take A, B, C anywhere in this branch, and let S_1 and S_2 be the points at infinity on the same branch. The two pencils S_1ABC and S_2ABC are projective, and hence, if D is a variable point on the curve, the range A′B′C′D′ (along as_2) is projective with the range A″B″C″D″ (along as_1). But A′B′ and A′C′ represent certain increments of the micrometer reading, and A″B″, A″C″ the corresponding known increments for the wave-length. Hence, knowing any other increment A′D′ of the micrometer reading, we can obtain the corresponding increment of the wave-length by putting the two ranges of points in perspective. The method has been tried at the Yerkes Observatory, and with the three-prism spectrograph gave results correct to about 0·001 Å.U. A. W.

222. *Spectra of Iron Vapour in Flames.* **G. A. Hemsalech.** (Phil. Mag. 33. pp. 1–18, Jan., 1917.)—The objects of the present research are: (i) To investigate the relative behaviour of the various types of iron lines by means of new observational and experimental methods. (ii) To gain some information with regard to the origin of the "cone" lines. (iii) To extend the observations to the spectra of the closely related elements cobalt and nickel. The present paper only deals with the first of these. The methods adopted were similar to those employed by Hemsalech and de Watteville [Abs. 1842 (1907)], but for feeding the flames two sprayers were used instead of the spark method previously employed. For the air-coalgas flame the high-pressure Gouy sprayer was used, and also a new low-pressure electric sprayer of which details are given. For the oxy-gas and oxy-hydrogen flames only the electric sprayer was used. The burners for the air-gas flame were made by drilling holes in plates of brass 3 mm. thick. One of these had 160 holes of 1 mm. diam., the centres being 1·5 mm. apart. The holes were arranged in 8 rows, consecutive rows being displaced so that the holes in one row came opposite the gaps in the adjacent rows. Another useful type had 12 holes of 2 mm. diam. arranged in two rows, the centres being 3 mm. apart. The direction of observation in this case was along the rows. For the oxy-gas and oxy-hydrogen flames ordinary mixed jets were used. The results of the observations were tabulated, and the lines were then divided into three classes: I. Lines which are emitted by the mantle of the air-gas flame, and gain in intensity on passing to the high-temperature flames. They are specially sensitive to thermal actions, and may be regarded as true temperature lines. II. Lines which are particularly sensitive to the special chemical actions of which the explosion region of the air-gas flame is the seat. They are also, though feebly, emitted by the outer mantle. In the flames of higher temperatures their intensities increase, showing that they likewise respond to thermal changes, but to a lesser degree than the lines of Class I. III. This class contains the bulk of the cone lines which form what the author and de Watteville have called the supplementary spectrum. Tables are given of the lines in Classes I and II. After a simplification of the spectrum had been achieved in this way, search was made for possible relationships connecting lines, or groups of lines, of the same class. No evidence for the existence of series has so far been detected, but a number of groups of lines have been found in various parts of the spectrum. These groups consist of three, four, or more lines, the characters and relative positions of which are such as to suggest some orderly arrangement. A number of these groups are given.

A. W.

223. *Researches and Measures of Wave-lengths in the Red and Infra-red Regions of the Spectrum.* **K. W. Meissner.** (Ann. d. Physik, 50. 6. pp. 718–728, Aug. 8, 1916.)—The investigation was made as a preliminary to interferometer measures in the red region of the spectrum, in order to try to find a substance whose lines would serve better as a standard of reference than the iron lines, which become rather faint and infrequent in the region beyond 6400 Å.U. No satisfactory substitute was found, however. Photographic plates sensitive to the infra-red rays are prepared as follows:—0·1 gm. of dicyanin or dycyanin A is dissolved in 100 cm.^{3} of heated absolute alcohol in a vessel protected against light and shaken violently. Then 3 cm.^{3} of this solution is mixed with 50 cm.^{3} of ordinary alcohol, 50 cm.^{3} distilled water, and 6 cm.^{3} strong ammonia. Ordinary dryplates are immersed in this bath for 3 mins. at temp. 20°–22° C.; then their backs are wiped dry, and they are placed on a tank of water at 35°, and dried in a current of hot air in about 2 mins. The plates are much more sensitive when dried quickly; hence it is important that the air in the dark room should be kept dry, and at about 22° C. Plates prepared by this process retain their sensitiveness for 4 or 5 days, but are most sensitive the second day. Of various makes tried Wratten and Wainwright's plates gave by far the best results. A tendency to spreading of images may be counteracted by washing the plates after sensitising, in a bath of equal parts of alcohol and water, to free the film from superfluous matter. The plates are developed with glycin (1 : 10) in 20–30 mins. When high resolving power is required diapositive plates may be used ; for these only 3 cm.^{3} of ammonia should be added to the sensitising bath and its temp. should not exceed 20° C. The backs should be left unwiped, and the plates simply dried in a hot-air current, with no tank. After exposure they should be left 5 mins. in an alcohol and water bath, and then developed in 3 mins. with a rapid developer. Most of the measures were made by the method adopted by Lorenser [Tübingen Dissertation, 1913] with Runge and Paschen's apparatus. The substances examined were Cs, Fe, Na, K, Rb, Al, Ca, Ag, Cu, Cr, U, S, O. The cæsium spectrum was examined both with the arc in air, and arc in vacuum, and striking differences were found in the Bergmann series in the two cases. With arc in vacuum, the lines are much sharper than with arc in air, but the series shows no novelty of structure, consisting of pairs with constant frequency-difference (97·75). But with arc in air each strong pair appears accompanied by another fainter pair having also frequency-difference 97. These faint pairs are even less sharp than the stronger pairs ; their sharper edge lies towards the side of longer wave-length, that of the stronger pairs towards shorter wave-length. The intensity of the fainter pairs relative to the principal pairs increases with the series number. It is noted that in the cæsium spectrum contained in Table XX of Eder and Valenta's "Atlas of Typical Spectra" three terms of the Bergmann series may be seen, one accompanied by a faint pair. Eder omits the line 8521·18 Å.U. of cæsium ; his rubidium line 8521·21 belongs to cæsium, and his cæsium line 7800·11 appears to be really rubidium 7800·3. Search for members of the Bergmann series was made in the red spectra of other substances, especially potassium and rubidium which should have shown some of the terms, but no traces of them could be obtained. In the case of aluminium, with arc in air, three terms of the Bergmann series were shown on the plates, but consisted of doublets so close that they could only be measured as single lines. In the iron spectrum only three lines were found below w.l. 8824 ; strange to say two of these do not occur in the solar spectrum, which contains all the other known strong iron lines. The line 8893·75 given with a query in Kayser's list of iron lines was not found, and is probably not in the iron spectrum. The author believes Eder's values for two calcium lines, which deviate considerably from his own, to be erroneous. The uranium spectrum contains some strong lines which may possibly be useful as standards of reference in the red region ; none of them occur in the solar spectrum. The wave-lengths of the red lines of the substances examined are tabulated together with those obtained by previous observers ; in the case of cæsium a tabular scheme of the Bergmann series is added. A. E.

224. *Spectra of Neon and Argon.* **K. W. Meissner.** (Phys. Zeits. 17. pp. 549–552, Nov. 15, 1916.)—In this paper the author shows that in the spectra of neon and argon there exist systems of triplets and quadruplets with frequency-differences remarkably constant in the same system. Thus, in the neon spectrum three sets of triplets are found, the frequency-differences being respectively 1429·427, 417·451 ; 1429·428, 417·449 ; 1429·430, 417·449. There are also four sets of quadruplets, and these three triplets and four quadruplets include all the stronger lines of the red region with the

exception of the lines λλ5852, 6074, and 6402. The first member of the first quadruplet, λ8082, has not yet, however, been observed. A scheme is also given for the spectrum of argon, in which nine sets of quadruplets appear. Several of the lines have, however, not as yet been observed. A. W.

225. *X-ray Spectra of the Elements.* **E. Rutherford.** (Engineering, 102. p. 320, Oct. 6, 1916. Paper read before the British Assoc. at Newcastle.)—The paper contains a *résumé* of recent work carried out especially in Scandinavia and in the United States. As an introduction the earlier important work of Moseley (which contained a study of the spectra of 40 elements) in connection with atomic numbers is described in detail.

The American work has chiefly been done with the tungsten antikathode, with the aid of Coolidge tubes. This work, in addition to work of a similar nature by the author, is discussed, and its connection with the quantum hypothesis clearly demonstrated. In conclusion, it is stated that the penetrating power of γ-rays from RaC is much greater than that given by a Coolidge tube at the highest practical voltage. Thus it is shown how difficult it is to measure, by any known crystal methods, the wave-lengths of penetrating radiations of such high frequency. A. B. W.

226. *Interpretation of Röntgenograms and Röntgen Spectra of Crystals.* **A. Smits** and **F. E. C. Scheffer.** (K. Akad. Amsterdam, Proc. 19. pp. 432–438, 1916.)—M. v. Laue's (Bayer. Akad. Wiss., Ber., June, 1912) researches and those by W. H. and W. L. Bragg [Camb. Phil. Soc., Proc. 17. p. 1, 43 (1912)] on the diffraction of X-rays by crystals have given rise to the view about the arrangement of the atoms in the solid substance, which the authors consider irreconcilable with chemical ideas although in agreement with the physical properties of the substance. According to Bragg's theory the atoms of a solid substance occupy in a definite way the places of points of a lattice, in which arrangement the molecules no longer occur as separate particles—thus every solid phase both in the physical and the chemical sense is looked upon as one large molecule. It follows on this view that for solid NaCl the Na, like Cl, has a valency of six. "This fact is so very remarkable for the reason that importance is attached to the fact that the quadrivalency of the carbon atom would follow from the model for diamond."

Bragg's model for $CaCO_3$ is similarly criticised. The authors attempt to make clear that Bragg's model cannot be reconciled with the chemist's ideas of valency. From a consideration of the work of J. D. van der Waals the authors reach the conclusion that, "For a solid substance the distance between the atoms which belong to different molecules will depart very little from the distance between the atoms in the same molecule, which engenders the possibility that these small differences do not find expression in the Röntgenogram."

When special forces make their appearance, always between one Na and one Cl atom, the symmetry of the NaCl crystal can change. Bragg himself observed [Abs. 876 (1914)] that the model of NaCl given by him is not in harmony with the symmetry. The authors suggest that the occurrence of special chemical bindings is just in connection with this lower symmetry and indicates an alternative model of NaCl which takes into account the chemical factor—the valency of the elements. A. B. W.

227. *Energy Distribution in Spectra.* I. **R. T. Beatty.** (Phil. Mag. 33. pp. 49–63, Jan., 1917.)—In this paper a description is given of an investigation of the energy emitted by the lines of the spectrum of hydrogen in the visible region. The light from a Geissler tube was analysed by a monochromator, and its intensity was measured by a photoelectric cell which was calibrated by means of a carbon filament glow-lamp. Full details of the arrangement of the apparatus are given. Both water-vapour and pure dry hydrogen were used in the tube, and the photo-currents due to H_α, H_β, H_γ. H_δ measured. The observations were repeated at various pressures, and the results are tabulated and graphed. From these and other experimental results it is concluded that the energy distribution in the lines of the Balmer series is independent of the energy of the colliding electron or molecule which strikes it and causes it to emit these lines. Vegard's and Holtsmark's results for intensity-ratios of the hydrogen lines strongly support the above conclusion. Confirmatory evidence in the case of other spectra appears from the work of McLennan [Roy. Soc. Proc. 41. pp. 485–492 (1886), and 42. pp. 305–318, 574–584 (1887)] who has shown that in the spectra of Hg, Cd, Zn, and Mg caused by an electric discharge, the complete spectrum appears suddenly when the exciting electrons attain definite velocities. The author does not wish to exclude the possibility that under certain conditions electrons may possess such energy that they may excite one line only of the Balmer series, but takes the view that in a luminous discharge the great majority of the radiating atoms have been ionised, and give out light owing to subsequent recombination. The method of ionisation is taken to be immaterial as regards the distribution of light in different wave-lengths during such recombination. The intensity distribution will, however, be affected by the mean free path of the luminous atom and the nature of the molecules in its vicinity whose fields of force act on it. If the mean free paths of two luminous atoms H_α, H_β are less than the distances travelled by the atoms while emitting H_α, H_β, the intensity ratio will remain constant. At lower pressures when the free path of one atom is equal to or greater than this distance, the free path of the other remaining less than its distance travelled while emitting the corresponding line, the intensity-ratio will change. When the pressure is very low, so that the whole radiation from an atom can take place between collisions, the intensity-ratios should again become independent of the pressure. Experiments are now in progress to test this deduction, a Wehnelt kathode being used to produce a bright discharge in water-vapour at low pressure. The work will be continued by investigating the discharge at low pressures, and also the spectra of hydrogen compounds, such as HCl and H_2S, in order to elucidate further the variations in the energy distribution.

A. W.

228. *On Occurrence of Harmonics in the Infra-red Absorption Spectra of Gases.* **E. C. Kemble.** (Phys. Rev. 8. pp. 701–714, Dec., 1916.)—A continuation of work outlined previously [Abs. 289 (1917)]. The author attempts to show that owing to the lack of linearity in the law of force between the atoms in a diatomic molecule, the infra-red absorption band due to the vibration of these atoms along their lines of centres should be accompanied by a faint harmonic. The absorption bands at 2·34 μ and 4·66 μ in the spectrum of carbon monoxide are adduced as an example of such harmonics, and reasons are given for believing that the relation between their wave-lengths is not accidental. On the basis of the same theory, it is to be expected that at sufficiently high temperatures a new band should appear near the fundamental low-temperature band and the position of this band for CO is roughly computed. From the magnitude of the faint harmonic in carbon mon-

oxide, the author reckons that the force between the atoms must vary inversely as the 8·5th part of the distance between their nuclei.

The sharpness of the maxima of double absorption bands in the spectra of CO and HCl is incompatible with the new form of the quantum theory in which absorption is supposed to take place gradually and not by quanta.

C. S. G.

229. *Spectra of Carbon and Hydrocarbon.* **C. W. Raffety.** (Phil. Mag. 32. pp. 546–559, Dec., 1916.)—This paper gives the results of a photographic study of the Swan spectrum obtained from different sources, and is intended to direct attention to certain features which appear to be worthy of further research, namely, the physical significance of the changes produced in the spectrum by a change in the conditions of the source, and the origin of certain new lines and bands which have been recorded photographically. The arc between soft-cored carbons was struck within a flame of coal-gas in air, and this source gave some interesting results. Perhaps the chief interest of the spectrum thus obtained lies in the region λ4382 to λ4364, and in the hydrocarbon bands. In the former region are the three lines which appear to form part of the Swan spectrum and to be attributable to carbon. The brightness of these three lines changes considerably with the conditions of combustion, and their sympathetic variation with the carbon bands lends support to the conclusion that they have the same origin. A number of other sources were studied, and spectrograms are reproduced illustrating the various effects observed. In the spectrum of the Méker gas-flame the line-series are seen to be complex, and the whole system of bands is both beautiful and intricate. "The three" are strong and widened, and a close examination indicates a multiple structure. In the case of the hydrocarbon bands the most striking features, apart from the question of variation of relative intensities, appear to be the new companion lines to the isolated line of the flame spectrum about λ4324, which appears single with small dispersion. With the spark between carbon electrodes in air, with capacity but without self-induction, the line spectra of nitrogen and carbon are seen. In the case of the same spark within a flame of coal-gas there appear, in addition, the Swan bands of carbon, the flutings of cyanogen, and, less strongly, the hydrocarbon bands. The two spectra are thus superposed; but their relative intensities can be changed considerably by an alteration of the conditions of discharge. When sufficient self-induction is introduced into the circuit the line spectra of nitrogen and carbon disappear, leaving a bright Swan spectrum with "the three," the hydrocarbon bands and those of cyanogen. The spectrum then becomes practically identical with that of the arc-in-flame. A spectrum very closely similar is given also by the spark with self-induction in an atmosphere of coal-gas, the survival of the cyanogen bands being attributable, presumably, to an admixture of some nitrogen with the gas. The transformer discharge was also taken between Pt electrodes in absolute alcohol. The resulting spectrum shows a close agreement with the spectra of the arc and the spark in the coal-gas flame, and with the spark in an atmosphere of coal-gas. In addition, certain conspicuous new bands occur, some of which appear to be identical with members of Deslandres' negative groups. Their chemical origin is as yet unknown. The approximate wave-lengths of the heads of the bands are as follows:—λλ4102·5, 4068·0, 3854·0, and 3827·5. The bands of cyanogen are completely absent. In some spectrograms of the hydrocarbon bands obtained with a grating instrument, faint traces were detected of a new series of lines in the region between λ4107 and λ4025. Further investigation of this region with a prism spectrograph enabled the series to be observed more decidedly, and a wave-length table is given. In structure the faint series closely resembles the main series of the tail, but its scale is smaller. In the Mecker flame spectrum certain faint bands are visible between the green and the blue carbon flutings. The head of the first of these bands appears to be double, the wave-lengths of the two lines being λ4942·0 and λ4937·5. The second and stronger head is at λ4890 and a third head is indicated at about λ4858, but the most remarkable feature is the fluted structure of the band, the close and regular sequence of which can be traced nearly up to the carbon fluting (λ4737·2) in the blue. In addition to these bands, a well-marked single-line occurs at λ4748 close to the blue carbon band. The discovery of such variations and of new bands associated with the spectra of carbon and its compounds may be of importance in connection with astrophysics, particularly in the study of comets. [See Abs. 1681 (1914).] A. W.

230. *Complex Zeeman-effect.* **A. E. Becker.** (Astrophys. J. 44. pp. 236–243, Nov., 1916.)—The author of the present paper has been led by his investigations on series spectra to an explanation of the complex Zeeman-effect identical with the suggestion of Preston. The fundamental hypothesis is that the effect is due to complexity in the structure of the parent line, which is supposed to consist of a number of components of nearly equal frequency. It is assumed that the number of components in the parent line equals the number of *p*-components, each of the latter being accompanied by two *s*-components. Such a triplet is called a reduced triplet. The application of the hypothesis leads to the investigation of two propositions: (1) In any complex Zeeman-effect the number of *s*-components is twice the number of *p*-components. (2) These Zeeman components may be arranged in symmetrical reduced triplets, one for each *p*-component, of normal or nearly normal interval. Taking Voigt's scheme of complex types, it is found that eight of the twelve types satisfy both propositions; two others satisfy the first; another requires further experimental investigation; and the remaining one affords an experimental test of the truth of the two propositions. This case is where a circularly right-handed polarised component falls on a circularly left-handed polarised component. Such a double component should be unpolarised when viewed along the lines of force. This expectation was verified experimentally. In the spectrum of titanium, between λ5050 and λ3230, 67 lines were found showing complex Zeeman-effects of unquestionable character. Of these lines, 62 have twice as many *s*- as *p*-components, and of these 62 lines 70 % can be reduced to symmetrical triplets. Similar results were obtained for the iron spectrum. [See Abs. 857 (1912) and 1070 (1914).] A. W.

231. *Refraction of X-radiation.* **H. B. Keene.** (Phil. Mag. 32. pp. 603–604, Dec., 1916.)—Barkla's experiments carried out with the object of detecting the refraction of X-rays [Abs. 687 (1916)] have led to results which show that the refractive index of KBr for X-radiation ($\lambda = 0{\cdot}5 \times 10^{-8}$ cm.) is between 0·999995 and 1·000005. The writer of the present note some time ago carried out experiments in which a series of prisms were used in attempts to refract a beam of X-radiation. The prisms consisted of lead, aluminium, and sulphur, no attempt being made to obtain optically true surfaces. The general arrangement of the apparatus was similar to that adopted by Barkla.

An arrangement of lead slits gave an exceedingly narrow beam of X-radiation. Two series of eight prisms each were introduced side by side in the path of the beam, one set being arranged to produce refraction in the opposite direction to the other. Any evidence of refraction would be recorded by a lack of alignment of the two halves of the line image obtained on a photographic plate after several hours' exposure. No such evidence was obtained. A simple calculation showed that the refraction of X-radiation, if any, in these materials would correspond to a refractive index lying between 1·000005 and 0·999995. A. W.

232. *X-ray Spectra—produced by Bent Crystal Surfaces.* **P. Cermak.** (Phys. Zeits. 17. p. 556, Nov. 15, 1916.)—In an earlier paper of the same title [see Abs. 1350 (1916)] certain X-ray photographs were reproduced in illustration of the test. The author now considers that these photographs were not sufficient to fulfil that object completely. In the present paper an attempt is made to supply what was lacking in the earlier illustrations.

Photographs are shown of X-ray spectra obtained by means of artificially or naturally bent crystal surfaces, without rotation of the crystal during the exposure. Different results are obtained according to the conditions of bending the crystal, *i.e.* whether the curvature of the crystal structure is permanent, or is only temporary, or whether part of the crystal structure is completely destroyed.

In the spectra illustrated, sharp horizontal lines are to be seen crossing the "normal" spectrum lines (as obtained by the ordinary rotating plane-surface crystal). A. B. W.

233. *Diffraction of X-rays in Metals.* **K. E. F. Schmidt.** (Phys. Zeits. 17. pp. 554–556, Nov. 15, 1916.)—Debye has put forward a theory [see Abs. 1271 (1915)] on the scattering of X-rays, containing a reference to X-ray interference phenomena "which, by photographic means must appear as a series of rings of rapidly decreasing intensity," when X-rays traverse a sheet of matter. Such rings were first observed by Friedrich [Abs. 1290 (1913)] in the case of wax and paraffin. Debye and Sherrer [see Abs. 1130 (1916)] have also obtained similar interference effects, in which case X-rays were diffracted by rods of "amorphous" pulverised crystalline substances.

Following the line of research indicated by Debye, the author, in the present paper, gives the result of an investigation on the diffraction of X-rays by metal plates. Hupka [see Abs. 1829 (1913)] had already observed some indications of diffraction in the case of Pt and Au; but the author, unlike Hupka, finds perfectly definite and distinct diffraction effects for Al and Fe. With copper two interference rings, remarkably sharp and clear, are observed; with Al and Ag the rings are fairly sharp, whilst in the cases of Li, K, Na—Ni, Co, Fe—Sn, Zn, Pb, the interference patterns appear of different type with no distinct rings. Previous mechanical treatment of the metals, such as rolling, hammering, heating, has a marked effect on the interference patterns. In the case of copper only, so far as can be observed, the phenomena appear unaltered by such treatment—the two rings always remaining in the same relative positions.

The method of experiment is essentially that employed by v. Laue, Friedrich and Knipping in their work with crystalline plates. Individual cases are treated in detail, the peculiarities of the interference patterns—radii of rings, etc.—being noted in each case. [The dimensions of the rings give support to Debye's theory.] Reproductions of actual photographs are given as illustrations of the following cases:—(*a*) Copper—electrolytic, (*b*) copper—cast, (*c*) silver—hammered and heated, (*d*) Al—rolled, (*e*) Al—cast and hammered. A. B. W.

RADIO-ACTIVITY.

234. *Scattering and Absorption of γ-Rays.* **M. Ishino.** (Phil. Mag. 33. pp. 129–146, Jan., 1917.)—The object of the experiments described in this paper was to determine separately the coefficients μ (absorption) and σ (scattering) in the relation $I = I_0 e^{-(\mu + \sigma)t}$, where I_0 is the initial intensity of the beam and t the thickness of the plate. The relation between σ and the scattering materials has also been determined experimentally.

The results indicate that the mass scattering for each element is roughly of the same order of magnitude. The ratios $\frac{\sigma}{\rho}\Big/\left(\frac{\sigma}{\rho}\right)_{Al}$ and $\frac{N}{A}\Big/\left(\frac{N}{A}\right)_{Al}$ (where N is Moseley's atomic number of the element and A its atomic weight) for each element are very nearly equal. Evidence is obtained to show that even heavier elements scatter the gamma-rays of exceedingly short wave-length, like the light elements scatter the X-rays of comparatively long wave-length.

From a consideration of the results tabulated it is clear that the values of μ/ρ and σ/ρ are, for the elements examined, all about the same order of magnitude for the very penetrating gamma-rays for radium. Assuming the relation between absorption and wave-length found by Hull and Rice [see Abs. 1249 (1916)] the true absorption coefficient of gamma-rays in aluminium should be small compared with the scattering coefficient, but experimental evidence does not support this view.

The results indicate also that the mass-scattering for the gamma-rays of very high frequencies is far less than that for the ordinary X-rays. The scattering coefficient of the gamma-rays is comparable in value with the true absorption coefficient of an element. This difference between gamma-rays and ordinary X-rays indicates the importance of taking into account the scattering of gamma-rays in all measurements of their absorption in matter. A. B. W.

235. *Ionisation of Gases by α-Rays.* **H. A. Bumstead.** (Phys. Rev. 8. pp. 715–720, Dec., 1916.)—After discussing the phenomenon of the production of δ-rays when α-rays strike a metal plate, the author suggests that a similar emission of "δ-rays" might take place when gaseous molecules are ionised by α-rays. These swifter electrons would, in their progress through the gas, cause further ionisation. "Thus the column of ions produced by an α-particle would be made up of the tracks of many secondary electrons radiating irregularly from the axis of the column and extending only a small fraction of a millimetre from it; it would resemble the tracks of the X-rays as shown in Wilson's photographs but on a very minute scale; and with the ions and the electron trails densely crowded together."

Photographs of α-ray tracks in hydrogen (using a modification of C. T. R. Wilson's method) reveal these electronic trails radiating from the main column—these trails, as indicated above, are ascribed to δ-rays of high speed. On this view the large values of the initial diam. of the columns are readily explained. A. B. W.

HEAT.

236. *The Increase of the Quantity "a" of the Equation of State for Densities greater than the Critical Density.* **J. D. van der Waals.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 859–867, 1916.)—Already in 1873, when drawing up the equation of state, the author realised that it must follow from the derivation from the kinetic theory that the quantity *b* would have to decrease with diminishing volume. Accordingly the author stated that *b*, which represents four times the molecular volume at infinite volume, would have to decrease. Afterwards the opinion was expressed that it would have to diminish to twice that volume, or even to a still smaller value. That *b* decreases is pretty generally accepted at present, but its cause is, in the author's opinion, often sought in a wrong direction, viz. in the real diminution of the molecule. Not until 1910 did the author express doubt of the invariability of the quantity *a*, and he ascribed the variation to what he termed "quasi-association or molecule complexes." The view that the cause for this increase of *a* is an enlargement of the molecule, as is the case for real association, is still considered correct, but the possible complexes were treated approximately as for real association, a method now discarded by the author. In the present paper the idea is developed that the cause for this increase of *a* must be sought without molecule complexes being necessary, but as a consequence of the ordinary regular molecular movement of molecules which have extension. So long as the distance of the molecules is great enough to allow the passage, *a* does not change, or inappreciably little, and when the mean distance is small enough to prevent this passage there is a reason to cause appreciable increase of *a*. The assumption of complexes also implies departures from the normal state, and it is demonstrated that the increase of *a* at greater densities already follows on the supposition that the distribution of state is perfectly normal. The author shows that for the latent heat it is of importance to keep apart the two cases, viz. space between the molecules greater or smaller than the dimensions of the molecule itself. In general the transition case is that for which the distance of the molecules is equal to the dimension of the molecule.

H. H. Ho.

237. *An Adiabatic Calorimeter.* **F. Daniels.** (Am. Chem. Soc., J. 38. pp. 1473–1480, Aug., 1916.)—The calorimeter is made of sheet metal, enclosed in a sheet-metal jacket and provided with a metal cover, ground to fit the calorimeter like a stoppered bottle. It is immersed completely in a large metal bath, also lagged to check loss of heat on radiation and conduction, and filled with water. The water in the outer bath is heated by an alternating current passing through the water between the metal walls of the case and the metal walls of the calorimeter-jacket. Differences of temperature between the water in the calorimeter and in the bath are recorded by a thermo-couple consisting of 8 copper-constantan junctions packed in paraffin and enclosed in a tapering sheath of very thin glass. Using this device, the difference of temperature between the calorimeter and its environment can be kept within 0·01 deg. when the temperature is rising at the rate of 0·2 deg. per min., or 0·02 to 0·03 deg. when it is rising at the rate of 1 deg. per minute.

An automatic control by means of a selenium cell is described, but is not quite so sensitive as regulation by hand.

T. M. L.

238. *Relation between the Melting-point of Palladium and Wien's Constant* c_2. **G. Holst** and **E. Oosterhuis.** (K. Akad. Amsterdam, Proc. 19. pp. 549–550, 1917.)—Recent experimental work has established the value of L in the equation $c_2(1/T_1 - 1/T_2) = L$, as 2·888 with a very small probable error, T_1 and T_2 being the melting-points of Au and Pd respectively. Hence to any given value of the melting-point of Pd a definite value of c_2 corresponds. Thus if the melting-point of Pd is taken as 1549° (scale of Day and Sosman) c_2 must be taken equal to 14,465 ± 5. If, on the other hand, c_2 is taken as 14,300 (Reichsanstalt scale) it follows that the melting-point of Pd is 1557°.

J. W. T W.

239. *Distribution of Angular Velocities among Diatomic Gas Molecules.* **E. C. Kemble.** (Phys. Rev. 8. pp. 689–700, Dec., 1916.)—The author, in this mathematical paper, develops a formula for the distribution of angular velocities among diatomic gas molecules on the basis of the classical statistical mechanics, and shows that his formula is in agreement with the observed shape of the band at 4·6 μ in the infra-red absorption spectrum of carbon monoxide, for which diatomic gas alone the necessary data are available.

On the basis of this new distribution law, he further shows that the expression for the moment of inertia of a diatomic molecule in terms of the frequency of rotation ν_r corresponding to the maxima of a Bjerrum double band is $I = RT/4\pi^2\nu_r^2N$ and not $I = RT/2\pi^2\nu_r^2N$.

Finally it is shown that this new formula for the moment of inertia agrees with Ehrenfest's assumption that the quantum for rotational energy should be $\frac{1}{2}h\nu$ instead of $h\nu$.

C. S. G.

240. *Note on P. Scherrer's Calculation of the Entropy-constant.* **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 19. pp. 546–548, 1917. Supplement No. 41*b* to Comm. from Phys. Lab., Leiden.)—The object of this note, which is suggested by a remark made by W. H. Keesom, is to point out that: (1) If a model of a monatomic gas, constructed according to the theory of quanta, on cooling at constant volume ceases to conform to the classical theory at temperatures which are too low (*i.e.* lower than is indicated by experiment), it will also give values for the entropy-constant which are too high, unless the entropy is not taken as zero at the absolute zero of temperature for ideal gases. (2) The model suggested by Scherrer remains ideal down to temperatures far below the allowable limit. The author considers how this said temperature is determined in Scherrer's model. The equation of state corresponding to the model is obtained from the formula for the entropy, which Scherrer derives from the value of the thermodynamic probability of the system; the latter is completely determined, except for a constant factor, by the number of elementary cells in the phase-space of the system which lie inside the hyper-surface of constant energy. For large values of the energy, *i.e.* for high temperatures, this number may be calculated approximately by dividing the volume of an elementary cell into the volume enclosed by the energy-surface, and so the equation of state of the ideal gas is obtained. It is therefore necessary to make an estimate of the possible error in this calculation for small values of the energy. The author concludes that the cause of the gas-model remaining ideal at temperatures which are too low must be looked for in the small frequency of the vibrations.

H. H. Ho.

SOUND.

241. *Vibrating Telephone Diaphragms.* **A. E. Kennelly** and **H. O. Taylor.** (Am. Phil. Soc., Proc. 55. pp. 415–460, 1916.)—An elaborate research, the paper being illustrated by a number of diagrams which should be seen for a full appreciation of the details. The chief results may be summarised thus :—(1) The depression angles of the diameter of a telephone receiver's motional-impedance circle are not closely connected, and are differently affected by impressed frequency. (2) Both the vibration galvanometer and the oscillograph have a motional-impedance circle and a corresponding useful series of motional constants. (3) The motional-impedance circle of a telephone receiver may sometimes reveal a distortion, accompanied by an absorption and a suppression of power. (4) A distortion in the form of a re-entrant loop is attributable to the existence of a secondary or dependent vibratory system, having its own motional constant and resonant frequency. (5) A distortion in the form of a general flattening of the impedance circle might be accounted for by the existence of secondary vibration in a dependent attached system. (6) An experimental form of coupled multiple pendulum is described, which affords a visual manifestation of the essential phenomena of the motional-impedance circle. [See Abs. 1715 (1915).] E. H. B.

242. *Sound and Electric Currents and their Analogies.* **W. Hahnemann** and **H. Hecht.** (Phys. Zeits. 17. pp. 601–609, Dec. 15, 1916.)—This is a mathematical treatment in which the analogies are traced between sound-radiation and electric currents through various circuits. It is thus shown that the following relations hold.

A plane acoustical field has its electric analogue in a pure resistance, a converging field in a capacity and resistance, a diverging field in an inductance and resistance.

As the electric voltage and the current are in the three cases in like phase, advanced and retarded respectively, so in the three acoustical cases are the pressure and velocity similarly related.

As in electrical phenomena the quotient of voltage to current measures the resistance, so in acoustical phenomena the quotient of pressure and velocity measures the property which is here called *sound-hardness.* Such bodies are analogous to insulators. What are called *sound-soft* substances are analogous to good conductors. E. H. B.

243. *Tuning-fork Recorder of Complex Wave-forms.* (El. World, 68. p. 1287, Dec. 23, 1916.)—Hitherto, by impressing upon an electrically-controlled fork an alternating current of complex wave-form the fork itself only responded to the fundamental and wholly disregarded the higher harmonics impressed upon the electromagnet. By means of mounting a tiny ball at the top of a series of graduated supports attached to each other in abutting relationship, A. Behm, of Kiel, according to U.S. Patent No. 1,208,172, has been able to produce a fork which can record both fundamental and any harmonics present in the wave. E. H. B.

244. *Vibrations, Waves, and Resonance.* **J. Erskine-Murray.** (Soc. Arts, J. 64. pp. 779–784, Oct. 6 ; 793–801, Oct. 13 ; 807–813, Oct. 20, and pp. 821–824, Oct. 27, 1916. Cantor Lectures.)—A general *résumé* of the subject, giving an account of the various experiments and models exhibited at the lectures for the purpose of illustrating the physical actions in the different acoustic and electric phenomena dealt with. L. H. W.

ELECTRICITY AND MAGNETISM.

DISCHARGE AND OSCILLATIONS.

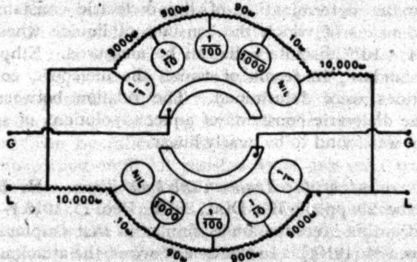
245. *Electrical Conductivity of a Bunsen Flame.* **N. H. Ricker.** (Phys. Rev. 8. pp. 626–632, Dec., 1916.)—These experiments resulted in the following conclusions. The variation of the current through the flame with the distance between the electrodes was investigated and plotted as a graph. As the distance is diminished, the decrease of the current was shown to be due to the current becoming saturated, and the volume decrease causing a decrease in the current. The curve reaches a minimum and then rises again. This rise is explained by the intense field increasing the thermionic current, and was shown not to be due to ionisation by collision. E. H. B.

246. *Properties of Slow Canal Rays.* **A. J. Dempster.** (Phys. Rev. 8. pp. 651–662, Dec., 1916.)—This is an account of experiments with positive rays under more varied pressure conditions and of slower speed than those generally used. In the usual canal-ray tubes the potential is limited very largely by the vacuum; for instance, if the pressure is about 0.005 mm. of mercury, the potential with ordinary tubes is of the order of 20,000 volts. In this investigation the subject was first approached from the side of the light emission, and later the analysis by electric and magnetic deflection was made. The method of ionising the gas by means of electrons from a Wehnelt kathode is used in the present experiments, and found to afford the following experimental advantages, namely: the possibility of producing positive rays of any desired speed in a constant vacuum, and the possibility of changing the pressure over a wide range with constant speed of the rays. It is found that positive rays excite light down to a speed less than that corresponding to a fall through 5 volts. They may be completely deflected by an electrostatic field. Neutral rays in hydrogen excite light down to a speed corresponding to 50 volts. The theory that light is excited only during the return of a corpuscle to a positive centre does not cover this case of light excitation. The light caused by both the neutral and positive rays contains the hydrogen series lines. It is probable that neutral rays of 800 volts' speed are able to change into positive. Saturation curves are given for ionisation by positive and neutral rays. An apparatus for analysing positive rays down to 90 volts' speed by the electric and magnetic deflection method is described. At high vacua H_1 and H_3 are negligible in comparison with H_2, indicating that electrons ionise by detaching a single elementary charge from the neutral molecule; that the impact of positive rays is necessary for dissociation; and that H_3 is formed only when the gas is in a dissociated state. A. E. G.

247. *Mobilities of Gas Ions in High Electric Fields.* **L. B. Loeb.** (Phys. Rev. 8. pp. 688–650, Dec., 1916.)—The mobilities of the gas ions are measured by the Franck modification of the Rutherford alternating-current method, and the apparatus is essentially of the usual type. The potential and frequency of the alternations of current are kept constant and the distance between the electrodes varied, as neither the magnitude nor frequency of the alternating potential can be varied through sufficiently wide limits. The actual velocity of the ion in high fields is great, and the distance between the plates must be small enough to keep the electric field uniform so that a very high frequency is necessary. This frequency is finally obtained by utilising the resonance circuit of the Chaffee arc [Abs. 1258 (1912)]. The arc is supposed to give an undamped sine wave, and is assumed to do so in computing mobilities. The range of gas pressures worked with extends from 800 mm. to 750 mm, the field strengths from 5160 volts/cm. to 12,450 volts/cm. at a frequency of 7670 alternations per sec. It is found that neither the mobility of the positive ion nor of the negative ion shows any tendency to abnormal increase over the range of pressures and field strengths used, and the negative ion shows no tendency to increase in mobility relatively to the positive ion. The fields used are nearly powerful enough to cause ionisation by collision, but no sign of any "break-up" of the ion is detected. The results are in agreement with the recent results of Wellisch [see Abs. 1099 (1915)], obtained at low field strengths and very low pressures, in leading to the conclusion that the "cluster" theory of the ion is no longer tenable. T. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

248. *New Constant-current Universal Shunt.* **H. W. Brown.** (El. Rev. 79. p. 480, Nov. 3, 1916.)—The author describes a new type of shunt which he has designed, based upon the principle of the Wheatstone bridge, but with one pair of arms cross-connected so as to obtain a continuously increasing reading with increase of displacement from the neutral point. The arrangement is obvious from the Fig. here reproduced. The movable switch connecting the respective segments to the contact studs is not shown. The advantages claimed are, first, that the only moving contacts are in the galvanometer circuit; secondly, that the main current is kept constant, no matter what shunt is being used. L. H. W.



249. *Thermoelectric Properties of Fused Metals.* **C. R. Darling** and **A. W. Grace.** (Phys. Soc., Proc. 29. pp. 82–89; Disc., 89–90, Dec. 15, 1916.)—The thermal e.m.f. of bismuth against various metals was investigated over the temperature range 104° to 558° C. The bismuth was contained in a salamander crucible inserted in a sheet of uralite so as to leave the upper rim projecting about 5 mm. A groove was cut in the uralite and a corresponding groove filed in the crucible so that the molten metal could overflow into the channel in the uralite. This channel was filled with bismuth to a distance of about 50 cm. from the crucible where a cold junction was formed with the metal under test; this being fused into the solidified bismuth. The hot junction was made by dipping the metal directly into the crucible, or in cases where the metal was attacked by the Bi, by surrounding the wire in a tight graphite sheath which was immersed in the crucible.

Temperatures were measured with an iron-constantan junction dipping into the crucible. The metals copper, iron, aluminium, nickel, brass, silver, constantan, German silver, nichrome, graphite, and platinum were employed for the second metal of the couple. In every case there was an abrupt change in the e.m.f. temperature relationship at the melting-point; with copper, a small but steady increase of e.m.f. after fusion, with silver a practically stationary e.m.f. between 300° and 500°, and with nickel a rapid fall of e.m.f. Iron, aluminium, and nichrome resemble silver in producing a stationary or nearly stationary e.m.f. with fused bismuth. German silver and constantan give curves resembling that of nickel; whilst graphite and platinum show a more gradual but continuous fall in e.m.f. after the bismuth has melted.

The authors suggest that the nearly constant e.m.f. observed with silver, aluminium, iron, and nichrome, with molten bismuth over a range of nearly 200 deg. C., of the order 16 millivolts, might prove of practical utility.

Numerous little kinks were observed in the curves which could not be explained. E. G.

250. *Dielectric Constant of Aqueous Solutions.* **E. A. Harrington.** (Phys. Rev. 8. pp. 581–594, Dec., 1916.)—A modification of the Nernst apparatus for the determination of the dielectric constant of liquids is described, by means of which the constant of liquids whose conductivity is as high as 1×10^{-6} absolute units can be measured. Ethyl bromide was used as the standard, in terms of which the dielectric constants of the aqueous solutions were determined. The relation between the concentration and the dielectric constants of aqueous solutions of sugar, urea, and methyl alcohol was found to be nearly linear. T. S. P.

251. *Measurement of the Thomson-effect in Wires.* **H. R. Nettleton.** (Phys. Soc., Proc. 29. pp. 59–79; Disc., 80–81, Dec. 15, 1916.)—The principle of the method in this investigation is similar to that employed by Berg for plates [see Abs. 984 (1910)]. In the case of wires, the attachment of thermocouples is to be avoided, since the alteration of electrical resistance per unit length and the distortion of the lines of heat flow would be serious. The apparatus designed by the author overcomes these difficulties. One end of the wire passes through the centre of a thick copper plate which forms one side of a steam chamber. Good contact between wire and copper are obtained by soldering, but precautions are taken to prevent the spread of the solder along the portion of the wire external to the copper. The other end of the wire passes through a similar plate which forms one side of a vessel containing ice or water at room temperature. The distance between these plates is about 5 cm., and the temperature gradient is obtained by thermo-elements inserted in holes drilled in the copper. The wire is lagged with cotton-wool to prevent heat losses by convection currents. Surrounding the wire at its centre is a small coil of copper which serves as a resistance thermometer. A steady temperature difference between the ends of the wire is established and a current C_1 passed. The temperature distribution along the wire alters, owing to Joule and Thomson-effects. Heat due to Peltier-effect is negligible in this apparatus [König, see Abs. 1068 (1916)].

The copper resistance thermometer is balanced on a bridge. The current is now reversed and at the same time altered to C_2, this value being such that the change in the Joule heat and the reversed Thomson-effect maintain the temperature distribution at the centre of the wire the same. This is indicated by the resistance thermometer remaining balanced. The author shows theoretically that the Thomson-effect σ is then given with sufficient accuracy by the expression $\sigma = (R/4{\cdot}18U)(C_2 - C_1)$, where R is the resistance between the ends of the wire under the temperature conditions of the experiment and U = temperature difference between the ends. The following results are obtained at a temperature of 60° C. :—

Constantan	−4·72	microcalories per coulomb per 1 deg. C.
German silver	−2·35	„ „ „
Manganin............	+0·68	„ „ „

L. L.

252. *Preliminary Note on Four New Instruments.* **P. Barreca.** (N. Cimento, 11. pp. 305–315, May–June, 1916.)—The principles of four instruments—(*a*) an electro-dynamometer ; (*b*) a capillary electrometer ; (*c*) and (*d*) microbalances—are described, but, owing to the demands of his other work, the author has not had time to experiment with them. He suggests difficulties that may arise in constructing and using them, in case any one cares to undertake the practical work. V. C.

253. *Universal Resistance-standardising Bridge.* **C. V. Drysdale.** (Electrician, 78. pp. 416–419, Dec. 29, 1916 ; pp. 441–445, Jan. 5, and p. 478, Jan. 12, 1917.)—The chief feature of the bridge is the adaptation of the well-known Cary Foster slide-wire method to the Kelvin double bridge and the adjustments of two slide wires so as to give the difference between the resistances under comparison directly in millionths of their value. By means of specially built-up standards and ratio coils on Rayleigh's principle, the bridge also serves for standardising coils of intermediate values and for stepping up or down by ratios of 10 to 1 or 2 to 1. The bridge forms a complete standardising outfit for resistances of any value from a microhm to a megohm over a range from 0·001 ohm to 1000 ohms. An accuracy of one part in a million is obtainable. In making connection between many of the coils, especially the ratio coils, massive copper plugs terminate the coils. The plugs are faced off so as to be exactly flat and level. The upper surfaces of the plugs are amalgamated, and two heavy copper connecting pieces are provided with amalgamated lower surfaces which make the necessary connections with a minimum of contact resistance. Details of a large number of measurements are given. [See Abs. 2106 (1907).] F. E. S.

254. *Self-recording Electrometer for Atmospheric Electricity.* **W. A. D. Rudge.** (Cambridge Phil. Soc., Proc. 19. pp. 1–10, Jan., 1917.)—The instrument follows the principle of the quadrant electrometer, and has been devised with a view to cheapness and simplicity of construction. The record showing the deflections of the needle is made photographically upon bromide paper on a clock drum which can be made to rotate either once in one hour or in twelve hours by a simple mechanism. A radium collector was used in connection with the electrometer, and curves are reproduced which show the variations in atmospheric potential gradient in the vicinity of roads and railways near Cambridge. The effect of steam from passing trains and dust raised by vehicles in temporarily increasing the positive potential gradient is clearly shown. J. S. Di.

ALTERNATING CURRENTS AND MAGNETISM.

255. *Sunlight and Magnetisation.* **F. C. Loring.** (Science, 44. pp. 635–637, Nov. 3, 1916.)—Referring to the work of Faraday and of Maxwell, the author still wonders if the sunlight or radio-active phenomena have any effect on the magnetisation of a magnetic needle. It is felt desirable that this point should be investigated in the light of modern electrical theory and that the results of Nipher's experiment of 1913 should be published. E. H. B.

256. *Sun-spots and Magnetic Storms.* **A. L. Cortie.** (Engineering, 102. pp. 319–320, Oct. 6, 1916. Paper read before the British Assoc. at Newcastle.)—In the association of sun-spots and magnetic storms, besides spot area and activity, a third factor could be studied, that of sun-spot position. Results are communicated of an investigation of the Stonyhurst magnetic records for the 25 years 1889–1913, embracing two complete solar cycles, and data for 2028 sun-spots. In general, spots near the solar equator exercised a stronger magnetic influence than those of higher latitude, but spots in the zones 25–30° latitude seemed exceptionally powerful. It is suggested that spots ejected electrons, which on repelling each other formed clouds; when these clouds encountered the earth the upper air would be ionised and rendered more conducting; then the energy of the e.m.f. would be supplied by the rotation of the earth as suggested by Schuster, and a magnetic storm would be experienced. C. P. B.

257. *Effect of Temperature on Magnetisation.* **K. Honda** and **J. Ôkubo.** (Tôhoku Math. J. 5. pp. 325–338, Dec., 1916.)—An extension of a previous paper on the molecular theory of magnetism [see Abs. 1287 (1916)], for the purpose of considering the effect of thermal motion on the intensity of magnetisation. It is commonly admitted that the diminution of magnetisation at high temperatures is due to the rotational vibration of molecules, and that when the motion becomes one of continuous revolution magnetisation disappears. But it is questionable whether the change of amplitude alone is sufficient to explain the A2 transformation. Considering the case when the external field is very strong, it is shown that simple revolutions of molecules round their own centres are not sufficient to account for the disappearance of magnetism at the critical point. The cause of discrepancy between theory and experiment is sought in the fact that there had been assumed no transformation either in the molecules or in their mutual configuration. A consequence of the authors' theory in the case of magnetite is that the distance between two consecutive molecules is about four times greater than the dimension of the molecules. G. E. A.

258. *Subsequent Magnetism of Iron.* VI. **A. Bernini.** (N. Cimento, 11. pp. 377–390, May–June, 1916.)—Further experiments on two samples of Swedish iron, one in bar form and the other as a bundle of wires [see Abs. 116, 117 (1915)], lead to the following results. With fields of 0·001 to 20 units the subsequent magnetism on demagnetisation of the newly reheated samples is represented well by the equation, $\psi = A'(1 - e^{-\lambda' t^{1/3}})$—identical with that established for subsequent magnetism on magnetisation—where A′ and λ′

assume values varying with the experimental conditions. With increase of the field, A′ and λ′ increase together according to indefinite laws. With fields up to 8 units, the values of λ′ are smaller for the subdivided field, whilst with more intense fields the reverse is the case. Whatever the value of the field, A′ is always greater in the bar than in the subdivided sample. The ratio of the subsequent magnetism to the total induced magnetism diminishes with the strength of field, but is always greater for the bar than for the bundle of wires. As the strength of field increases (1) λ exhibits inversion, whereas λ′ almost always shows regular charge; (2) A reaches a maximum, while A′ increases continuously; (3) the ratio of the subsequent to the total magnetism diminishes continuously in the case of magnetisation, but attains a constant value in the case of demagnetisation. T. H. P.

259. *Application of Kerr-effect to Determine Saturation Values of Magnetisation.* **S. G. Barker.** (Phys. Soc., Proc. 29. pp. 1–31; Disc., 31–32, Dec. 15, 1916.)—The paper deals chiefly with the redetermination of Du Bois' dispersion curves for the magnetic metals in the visible spectrum. The particular case of normal reflection and normal magnetisation is used; the rotation of the plane of polarisation is then dependent only on the wavelength and on the strength of the magnetic field. As a consequence from Du Bois' theory, the rotation ϵ will become constant when maximum magnetisation is reached. The saturation values were found, and, by plotting rotation against field, the point of intersection of the straight line, $\epsilon = KH/4\pi$, and the asymptote, $\epsilon =$ constant, gave an abscissa whose value was $4\pi I_m$ where I_m is the saturation value. The values found agreed with those found by other methods. Numbers are first given for three specimens of iron from different sources; the values of I_m all ranged about 1700 c.g.s. In the case of electrolytic cobalt the value obtained for I_m was about 1400, and that for nickel about 500 c.g.s. Dispersion curves for the specimens are also given. Other materials examined were ferromanganese and numerous other alloys and magnetite which has a value of I_m of about 400. In the *discussion*, **P. E. Shaw** pointed out that, in order to obtain rotation effects of fair magnitude, it would seem to be necessary to deal exclusively with materials of ferromagnetic strength, and even then to employ great fields. G. E. A.

260. *Magnetic Properties of Hematite.* **T. T. Smith.** (Phys. Rev. 8. pp. 721–737, Dec., 1916.)—A description of tests made, with fields up to 3800 gauss, on crystals of hematite obtained from various sources in Europe and America. The method employed depended on the measurement of the force exerted on a small inductively magnetised sphere in a non-uniform field, the working formula being $F_y = I_x \frac{\partial H_x}{\partial y} v$, where F_y is the mechanical force along the y-axis exerted on an element of volume v. Cylindrical pole-pieces were used on the electromagnet which supplied the field, as they gave a nearly constant field-gradient over a considerable range. To measure the force F_y, a device was used in which the sphere bore on the centre of a disc of cover-glass, the bending of which was determined by the shifting of fringes in an interferometer. The specimens tested were divided into two general classes, viz., those which exhibit no signs of hysteresis and have an intensity of magnetisation proportional to the field in the direction of the axis of symmetry, and another group in which the hysteresis phenomena along the axis are particularly marked. In the first of the two classes the specimens are paramagnetic along the principal axis, and ferromagnetic in the principal plane of the crystal. In the second group the crystals are ferromagnetic in all directions, the intensity in the direction of the principal axis being considerably more than for the first group, and the intensity in the principal plane noticeably less. The experimental results are given under these two group divisions; for the first variety the values of the susceptibility obtained for the direction of the axis of symmetry were $0{\cdot}117 \times 10^{-3}$ and $0{\cdot}109 \times 10^{-3}$. G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

261. *The Radiographic Efficiency of the Coolidge X-ray Tube.* **W. S. Gorton** and **J. A. C. Colston.** (Am. J. of Röntgenology, pp. 3–8, Aug., 1916.)—It is generally assumed that the Coolidge tube does not give as good pictures as are obtained with the ordinary form of X-ray tube, and the reason, if any, assigned for this state of affairs has been the broadness of the focus of the Coolidge tube. In spite of this unfavourable verdict it seemed worth while, in view of the advantages offered by the Coolidge tube, to make a thorough investigation of its radiographic properties in order to determine precisely its efficiency as a radiographic agent, and also in the hope that a method of manipulation might be found which would place it on a par with the ordinary type of tube for radiographic purposes. The apparatus used was a 10-kw. transformer, a 7-in. tube of the ordinary type with a tungsten target, and a Coolidge tube of the medium focus type. This type was used instead of the fine focus type because the tube had been previously purchased for both radiographic and treatment purposes. The field of work was limited to the kidney, since pyelography is a difficult branch of radiography, and if it should be found that the Coolidge tube is suited to pyelography then it certainly should be suitable for less deep-lying structures. The plan of the work comprised exposures with the Coolidge tube on patients of various thicknesses under various conditions of current, spark-gap, and time of exposure, with and without a compression diaphragm, and with and without an intensifying screen; also some exposures with the ordinary type under various conditions. The outstanding result is that, on the average, the Coolidge tube gives as good pictures as does the ordinary type of tube used heretofore. The best pictures obtained are not quite as good as the best obtained with the ordinary tube, but the difference is very small. Better pictures are obtained with the use of a compression diaphragm than without one, and better results without an intensifying screen than with one. A surprising feature is the amount of time required for the exposures. For the same value of spark-gap and current through the tube the Coolidge tube is found to require an exposure two or three times as long as that required by the ordinary type of tube. This means that the ordinary tube under the conditions specified gives out a far larger quantity of X-rays than does the Coolidge tube. This does not mean that the latter is less efficient as a producer of X-rays; the condition is almost certainly due to the characteristics of the milliammeter. This instrument indicates an average value of all the instantaneous values assumed by the current. Now, in the Coolidge tube the current cannot increase more than a certain amount, whereas in the ordinary type there is a rough proportionality between the current and the voltage. The result is that in the ordinary tube a larger proportion of current passes when the voltage on the tube is high, thus producing a greater quantity of X-rays than is the case when the current has a limiting value. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

262. *Cutting and Chipping of Glass.* **Rayleigh.** (Engineering, 108, p. 111, Feb. 2, 1917.)—This letter to the editor was written with the object of obtaining further information on two matters relating to the working of glass. The writer points out that almost the only discussion of the cutting of glass by the diamond is a century old, viz., by W. H. Wollaston (Roy. Soc., Phil. Trans., p. 265, 1816). This is reproduced from the Abstracts, and the present writer then goes on to consider it in the light of mathematical solutions of related elastic problems by Boussinesq and Hertz, referring to Love's treatise on elasticity. Among the questions which suggest themselves, he asks whether the diamond cut necessarily involves a crushing at the surface, and what materials, besides glass, can be dealt with in this way; would a bending force, such as is afterwards applied to separate the parts, facilitate the original formation of the crack? The other matter about which the writer desires information is the preparation of "chipped" glass, the only mention of it being a casual one in Threlfall's "Laboratory Arts." In an experiment a glass plate was coated thickly with a warm solution of gelatine and allowed to dry on a levelling stand. After several weeks parts of the gelatine film had lifted, carrying up with them material torn away from the glass, and eventually there was but little of the original glass surface left. If the process is in regular use, the writer would like to know the precise procedure. It seems rather mysterious that a film of gelatine, scarcely thicker than thick paper, should be able to tear out fragments of solid glass, but there is no doubt of the fact. H. H. Ho.

263. *The System Iron-Carbon-Oxygen.* **W. Reinders.** (K. Akad. Amsterdam, Proc. 19. pp. 175–188, 1916.)—The three binary systems of the above ternary system have formed the basis of a considerable amount of study, and on the results the author has considered the equilibrium of the Fe—C—O series from a theoretical standpoint. Below 700° C. there are three monovariant equilibria, viz., (I) C, Fe_2O_3, Fe_3O_4 and gas; (II) C, Fe_3O_4, Fe and gas; and (III) C, FeO, Fe and gas. They are to be considered as the limits of stability of the following divariant equilibria: Fe_2O_3, Fe_3O_4 and gas; Fe_3O_4, FeO and gas; FeO, Fe and gas; and C and gas. Regarding the metastable carbide as a participating phase there are also a number of metastable monovariant equilibria of which the principal ones are (IV) C, FeO, Fe_3C and gas, and (V) FeO, Fe_3C, Fe and gas—representing the limits of the divariant equilibria FeO, Fe_3C and gas, and Fe_3C, Fe and gas. Between 880° and 1100° C. the conditions are changed consequent upon the formation of martensite. From 700° to 880° the solid solutions poor in carbon are metastable, so that the conditions are again changed. It is intended to investigate the most important points which have been deduced theoretically. F. C. A. H. L.

264. *Chemical and Physical Properties of Foundry Iron.* **J. E. Johnson, Jr.** (Met. and Chem. Eng. 15. pp. 530–537, Nov. 1; 588–597, Nov. 15; 642–646, Dec. 1, and pp. 683–685, Dec. 15, 1916.)—From his experience and researches, made in conjunction with L. Selmi, the author concludes that the tendency to eject carbon and to become softer does not stop when the iron solidifies, but continues at least down to the lower limit of red heat; this conclusion is in accord with the iron-carbon diagrams of Guertler-Wittorff and of Upton. He further ascribes a great influence on the strength, closeness of grain, and wearing qualities of the iron to oxygen. Having discussed the influence of graphite and of carbon on the properties (chiefly mechanical) of iron, he reviews the complex modifying effects of Si, S, P, O, Mn and of time, further of Cr, Ni, Ti, V, and summarises finally the compositions desirable for the chief varieties of foundry iron (distinguished as *a*, *b*, *c*, *d* below). An inquiry into the differences in quality between charcoal iron and coke iron suggested an investigation of the influence of oxygen, which was undertaken under the impression that oxygen was, next to sulphur, most detrimental. It resulted that low-temperature hearths give a stronger iron than high-temperature hearths; that the graphite of an electric furnace (high-temperature) iron which was very weak formed long streaks in the iron, when oxygen was absent, whilst in the presence of oxygen the solidification begins at higher temperature, but the segregation of graphite takes place at lower temperature and in nodules; that the oxygen also affects the form of the crystals of high-carbon iron and prevents the breaking-up of the cementite needles into ferrite and graphite, and further influences the matrix and the chilling. There are many photomicrographs to support these views. Hydrogen was absent from these irons, and nitrogen was apparently without influence; the other metals in iron might best be dispensed with, if it were not for the sulphur. The oxygen is purposely retained in the iron by keeping the temperature low in the converter; subsequent remelting does not remove the oxygen. The oxygen percentage was raised to 0·7 in some cases, whilst charcoal iron contains from 0·005 to 0·3 % O. Silicon and time favour graphitisation in general; sulphur should always be very low. Of the four varieties of foundry iron (*a*) for machine and general castings should contain from 1¼ to 1¾ % Si (more in small castings), up to 0·75 P, 0·6 to 1 Mn; the C percentage is not important except when special strength is desired; by adding scrap to the cupola charge (semi-steel), the strength is diminished; for dense castings high oxygen percentage is desirable; (*b*) chilled castings (car-wheels): Si should be low, S likewise, though authorities differ as to that; to keep the S out, the Mn percentage (from 0·4 to 0·8 %) may be raised; C should be high but not above 4 %, lest other factors reduce the strength; (*c*) malleable castings: Si 1 to 1·75 %, P up to 0·25 % (both these percentages are extremes); C as in (*c*); oxygen doubtful; (*d*) heat-resisting castings (ingot moulds); the graphite should be present in large flakes, the C be as high as possible; Si up to 1 or 1·5 %; P shortens the life of ingot moulds; Mn 0·4 to 0·8, but as oxygen has to be removed, a high manganese percentage or some thermal treatment may be required. H. B.

265. *Annealing of Carbon Steels as dependent on Temperature and Magnetic Flux.* **R. B. Fehr.** (Eng. Experiment Station, Pennsylvania, Bull. No. 18. Am. Chem. Soc., J. 39. pp. 82–84, Jan., 1917.)—A study of the range of temperature in which the various steel heat-treating operations should be carried out. An attempt was also made to determine whether there was any unusual effect on the physical properties of steel from being subjected to heat treatment and the action of magnetic flux simultaneously. The tests were made on ¾-in., round bars of 0·04, 0·28, and 0·835 % carbon steel, and the results are given in the form of tables and curves. These show practically no change in the physical properties due either to annealing temperature or to treatment with magnetic flux, except in the case of elongation. The results

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are therefore in accord with the known fact that low-carbon steels are very little affected by heat treatment. The author found that in all his tests the magnetic critical point indicated without exception the proper annealing temperature to give the finest grain, max. ductility and max. shock-resisting qualities. This temperature lies in all cases within 80 deg. above the critical temperature. By careful temperature control, a high-carbon steel can be given the ductility of a low-carbon steel and at the same time possess a higher elastic limit. G. E. A.

266. *Heat Treatment of Tools of High-speed Steel.* **A. E. Bellis and T. W. Hardy.** (Am. Inst. Mining Eng., Bull. No. 121. pp. 61-68, Jan., 1917.)—Describes some experiments on the hardening of five tool-steels of varying composition from different temperatures and illustrates the structure obtained by means of photomicrographs. As the temperature of quenching is raised, less and less free carbide is found in the resulting structure, whilst the overheated structure shows a coarse grain with black spots and wide intergranular spaces. In general the steels that show some excess carbide even at the max. hardening temperature are the most efficient: these as a rule are steels high in tungsten; they harden from a higher temperature and over a wider range than the low-tungsten steels. The steels with lower tungsten and higher vanadium give better results, when hardened at lower temperatures, than do high-tungsten steels hardened at the same temperature. C. O. B.

267. *Thermal Treatment of Aluminium Bronzes containing Ten per cent. of Aluminium.* **A. Portevin and G. Arnou.** (Rev. de Mét. 13. pp. 101-115, March-April, 1916.)—The authors have made a study of the influence of heat-treatment on the tensile properties, the resilience, the hardness, and the microstructures of two aluminium bronzes, A containing 90 % Cu and 10 % Al, and B containing 89 % Cu, 10 % Al, and 1 % Mn. Quenching from temperatures below 500° C. is without effect on the mechanical properties—a result which is in accord with the equilibrium diagram, which shows that the eutectoid point lies between 550° and 600°. Alloys quenched at 600° and 700° show a distinct increase in the strength, ductility, hardness, and resilience, so that the alloys are distinctly improved by this treatment from the mechanical and physical point of view. Quenching from higher temperatures increases the tensile strength and hardness but causes a diminution in the ductility and the resilience. The effects of reheating after quenching from 800° was then studied, and the results show that up to 400° reheating causes an increase in the strength and hardness, with a corresponding decrease in the ductility and the resilience. Above 400° the tensile strength and hardness decrease and the resilience increases to a value which is of the order of 4 times that of the untreated sample. Similar, but more definite, results were obtained with alloys quenched from 900°. The effects of heat treatment are more marked in the alloys containing Mn than in the straight Al bronzes. Microscopic analysis showed that the effect of quenching from above 600° developed a "martensitic" structure which became more and more pronounced as the temperature of quenching increased. The result of reheating is to develop a Widmanstätten structure, particularly in the alloys quenched from 900°. Some tests have been made on the partial substitution of Cu by Ni in a 10 % Al bronze. When the content of Ni attained 10 % the alloy could not be rolled by the methods usual for Al bronzes. The result of substituting Ni for Cu in small quantities is to increase the strength and to decrease the elongation.

F. C. A. H. L.

268. *Method for distinguishing Sulphides from Oxides in Steel.* **G. F. Comstock.** (Am. Inst. Mining Eng., Bull. No. 120. pp. 2108–2110, Dec., 1916.)—Shows that light-grey inclusions seen under the microscope, in steel specimens, although generally considered to consist of sulphides, are often oxides. As a result of experiments it was found that a boiling solution of sodium picrate attacked sulphide inclusions in steel, leaving black pits instead of the light-grey spots seen before etching, but had no effect on oxides and slags. Several examples are given, with photomicrographs, to illustrate the value of this etching agent in distinguishing sulphide inclusions from oxides and slags. C. O. B.

269. *Diffusion in Solutions.* **J. D. R. Scheffer** and **F. E. C. Scheffer.** (K. Akad. Amsterdam, Proc. 19. pp. 148–162, 1916.)—It has been shown by Einstein [Abs. 1909 (1905), 748 (1906), 1122 (1908)] that the mean square of the deviation of a Brownian particle and the diffusion constant depend on the nature of the substances and on the temperature. As regards the Brownian movement, the relation is expressed by $\Delta^{-2} = (RT/N)(t/3\pi a\eta)$, where N is the actual number of molecules in a gm.-molecule, *a* the radius of the particles and η the viscosity of the medium. Since the diffusion constant is given by $D = \Delta^{-2}/2t$, it follows that $D = RT/N6\pi a\eta$. The last expression may also be deduced directly by making use of the osmotic pressure and of Stokes' law. Einstein has, indeed, shown that for the cause of the diffusion may be substituted a force equal to the osmotic pressure acting on the diffusing particles.

In order to test the accuracy of the first and third of the above expressions, the authors have investigated the diffusion of mannitol solutions at various temperatures ranging from 0° to 70·2°. In order to avoid the difficulty of maintaining the temperature constant throughout the large apparatus usually employed, a micro-method was used to measure the amount of the solute which diffuses from the solution contained in a short capillary tube into the surrounding medium in a definite time. The numerical results obtained agree as well as can be expected with Einstein's formula. The latter gives $8{\cdot}9 \times 10^{-8}$ cm. as the mean value of the diameter of the mannitol molecule. T. H. P.

270. *Solubility.* **J. H. Hildebrand.** (Am. Chem. Soc., J. 38. pp. 1452–1478, Aug., 1916.)—Attention is directed to the extreme difficulty of predicting solubilities. As a basis of such predictions Raoult's law of the lowering of vapour pressures is considered to be more fundamental than van't Hoff's law, which makes the osmotic pressure numerically equal to that calculated for a hypothetical gas-pressure.

When Raoult's law holds for a mixture of two liquids it is possible to calculate the solubility of one as solid solute in the other as liquid solvent from the ratios of the vapour-pressure of the solute as solid and liquid at the temperature in question. In the same way, if the solute is gaseous, its solubility can be calculated from its vapour-pressure as a liquid at the same temperature, or if the temperature is above the critical point, then from an extrapolated vapour-pressure expressing its "fugacity."

Deviations from Raoult's law are ascribed primarily to inequalities of internal pressure and to polarity, thus non-polar liquids having approximately equal internal pressures obey Raoult's law and are subject to the previous generalisations. T. M. L.

271. *Specific Conductivity of Pure Water in Equilibrium with Atmospheric Carbon Dioxide.* **J. Kendall.** (Am. Chem. Soc., J. 38. pp. 1480–1497, Aug., 1916. Chem. News, 115. pp. 78–79, Feb. 16; 85–88, Feb. 23, and pp. 98–100, March 2, 1917.)—Highly purified water in contact with air possesses a specific conductivity of about 0·7 to 0·8 × 10^{-6} reciprocal ohms at 18° C. This compares very well with that calculated indirectly from (*a*) the ionisation constant of carbonic acid :—$k = 3{\cdot}12 \times 10^{-7}$ at 18° C.; (*b*) the mobility of the ion HCO_3, viz. = 40·1 at 18°, making the molecular conductivity at infinite dilution 354·0 at 18° C.; (*c*) the CO_2 content of the atmosphere = 3·58 vols. per 10,000; (*d*) the solubility of CO_2 :—absorption coefficient = 0·928 at 18°, solubility = 0·0414 gm.-mols per litre at 18°. These figures give a calculated conductivity 0·75 × 10^{-6} at 18° C. T. M. L.

272. *Thermodynamic Properties of Silver and Lead Iodides.* **H. S. Taylor.** (Am. Chem. Soc., J. 38. pp. 2295–2310, Nov., 1916.)—The thermodynamic relationships of the iodides of silver and lead have been studied afresh by investigating the cell Pb | PbI_2 | N/*x*KI | AgI | Ag. It is found that the value for the heat of the reaction, $Pb + 2AgI = PbI_2 + 2Ag$, as determined by means of the above cell, agrees satisfactorily with the best calorimetric data for the substances taking part.

The data obtained are used in an investigation of the assumptions of the Nernst heat theorem and of the methods of testing the same. As far as the present experimental evidence relative to specific heats may be employed, results favourable to the theorem are obtained. T. H. P.

273. *Electromotive Force developed in Cells containing Non-aqueous Liquids.* **J. M. Nelson** and **W. V. Evans.** (Am. Chem. Soc., J. 39. pp. 82–88, Jan., 1917.)—Organo-metallic compounds, like the etherates of magnesium alkyl halides or the so-called Grignard reagent, lower the electrical resistance of non-aqueous solvents such as dry ether or dry benzene. When a cell consisting of Mg and Pt electrodes dipping into a dry ethereal solution of ethyl bromide containing a small amount of previously prepared Grignard reagent is set up, an e.m.f. of 0·5–1·5 volts is immediately established between the terminals; in absence of Grignard reagent, the e.m.f. is zero at first but gradually increases as the organo-metallic compound forms in the cell. Similar behaviour is observed if Zn, Al, etc., is used in place of Mg. The dissolution of Mg in an ethereal solution of an alkyl halide thus appears to be analogous to the dissolution of a metal in an aqueous acid medium, and the question hence arises whether acids are not at first added to the metal, forming compounds similar to the Grignard reagent. T. H. P.

274. *Standard Cells and the Nernst Heat Theorem.* **F. M. Seibert, G. A. Hulett,** and **H. S. Taylor.** (Am. Chem. Soc., J. 39. pp. 38–52, Jan., 1917.)—The work here described was carried out in order to test the applicability of the Nernst heat theorem to the Weston standard cell and to a cell recently studied by Lipscomb and Hulett [Abs. 409 (1916)]. Careful determinations have been made of the e.m.f.'s and the temperature coefficients of these cells and of the specific heats between 87° K. and 274° K. of the cadmium salts involved, the specific heats of the other materials being already known. The experimental values are expressed as functions of the temperature with the aid of the Nernst-Lindemann specific heat equation. The values thus deduced have been utilised, along with others already available, to investigate the thermodynamic relationships of the cadmium sulphate standard cell and the cadmium chloride standard cell. Satisfactory agreement has been obtained between the calculated and observed values with Nernst's assumption for condensed systems and the consequent deduction that the integration constant in the thermodynamic equation is equal to zero. T. H. P.

275. *Occlusion of Hydrogen by a Palladium Kathode.* **D. P. Smith** and **F. H. Martin.** (Am. Chem. Soc., J. 38. pp. 2577–2594, Dec., 1916.)—Using a special apparatus, in which a Pd-wire kathode could be kept taut during the electrolysis of a 2-N solution of sulphuric acid, the authors have determined the changes in the electrical resistance and in the kathode potential of various wires, both during their occlusion of hydrogen evolved during the electrolysis and after the interruption of electrolysis. The wires used varied in diam. from 0·05 to 0·32 mm.; a ribbon of Pd, 0·018 mm. thick and 0·57 mm. wide, was also investigated. The increase of resistance (more than 56 %) at apparent saturation varies considerably, even with wires from the same lot of carefully purified Pd. Wires of 0·1 mm. diam. or less, and the ribbon, showed an increase in resistance after the interruption of electrolysis; there was also a change of resistance whenever the intensity of the charging current was altered either during the later stages of occlusion or after the attainment of saturation. The wire of 0·32 mm. diam. did not exhibit the effects given by wires of 0·1 mm. diam. Consideration of the results obtained lead the authors to the conclusion that the changes of resistance in the smaller wires are probably due to processes occurring within the metal, and not far removed from its surface. It is suggested that hydrogen occluded at the kathode surface exists for some time in a transitional state, in which it possesses an electrical conductance of its own, and passes gradually into another form which has much less, or no, conductance.

Details are given of characteristic changes, observed after the interruption of electrolysis, in the kathode potential of saturated Pd-wire, and certain connections have been traced between the manner and magnitude of these changes and the conditions of electrolysis.

Copper and nickel wires do not suffer any measurable alteration of electrical resistance under the same conditions which produce a high degree of occlusion in the case of Pd [see Abs. 1118 (1915)]. T. S. P.

276. *Overvoltage Tables.* IV. *Theories of Overvoltage and Passivity.* **E. Newbery.** (Chem. Soc., Trans. 109. pp. 1359–1368, Dec., 1916.)—The author gives a critical discussion of the results previously published in Parts I–III [see Abs. 179, 180 (1917)] and also in Abs. 229 (1915), and comes to the conclusion that overvoltage is probably due to the high solution potentials of compounds of the electrode material with the discharged ion or with a product of the discharged ion. These compounds tend to form solid solutions in the electrode substance, and are usually stable only under the influence of high pressures or high temperatures. A slight fall of overvoltage is produced by the inductive action of escaping ionised gas at high current densities, whilst greater diminution of the overvoltage is produced by breakage of the electrode surface, release of internal pressures, and subsequent decomposition of the compounds present. It is probable that compounds of the nature postulated play a considerable part in the production of thermionic currents. Passivity is considered to be due to the insolubility and good electrical conductivity of these compounds, which form a protective coating either over the whole metal surface or over the more easily soluble amorphous phase only. The coating may consist of the pure compound or of a solid solution of the compound in the electrode substance. It is shown, by reference to various electrochemical reductions, that the chemical stability of the higher oxides or hydrides formed on the surface of the electrode is of greater importance than the overvoltage when dealing with substances which are only oxidised or reduced with difficulty. T. S. P.